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Investigating The Relationship Between Adverse Events And Infrastructure Development In An Active War Theater Using Soft Computing Techniques

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INVESTIGATING THE RELATIONSHIP BETWEEN ADVERSE EVENTS AND INFRASTRUCTURE DEVELOPMENT IN AN ACTIVE WAR THEATER USING SOFT COMPUTING TECHNIQUES

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ABSTRACT

The military recently recognized the importance of taking sociocultural factors into consideration. Therefore, Human Social Culture Behavior (HSCB) modeling has been getting much attention in current and future operational requirements to successfully understand the effects of social and cultural factors on human behavior. There are different kinds of modeling approaches to the data that are being used in this field and so far none of them has been widely accepted. HSCB modeling needs the capability to represent complex, ill-defined, and imprecise concepts, and soft computing modeling can deal with these concepts.

There is currently no study on the use of any computational methodology for representing the relationship between adverse events and infrastructure development investments in an active war theater. This study investigates the relationship between adverse events and infrastructure development projects in an active war theater using soft computing techniques including fuzzy inference systems (FIS), artificial neural networks (ANNs), and adaptive neuro-fuzzy inference systems (ANFIS) that directly benefits from their accuracy in prediction applications. Fourteen developmental and economic improvement project types were selected based on allocated budget values and a number of projects at different time periods, urban and rural population density, and total adverse event numbers at previous month selected as independent variables. A total of four outputs reflecting the adverse events in terms of the number of people killed, wounded, hijacked, and total number of adverse events has been estimated. For each model, the data was grouped for training and testing as follows: years between 2004 and 2009 (for training purpose) and year 2010 (for testing). Ninety-six different models were developed and investigated for Afghanistan

and the country was divided into seven regions for analysis purposes. Performance of each model was investigated and compared to all other models with the calculated mean absolute error (MAE) values and the prediction accuracy within ±1 error range (difference between actual and predicted value). Furthermore, sensitivity analysis was performed to determine the effects of input values on dependent variables and to rank the top ten input parameters in order of importance.

According to the the results obtained, it was concluded that the ANNs, FIS, and ANFIS are useful modeling techniques for predicting the number of adverse events based on historical development or economic projects' data. When the model accuracy was calculated based on the MAE for each of the models, the ANN had better predictive accuracy than FIS and ANFIS models in general as demonstrated by experimental results. The percentages of prediction accuracy with values found within ±1 error range around 90%. The sensitivity analysis results show that the importance of economic development projects varies based on the regions, population density, and occurrence of adverse events in Afghanistan. For the purpose of allocating resources and development of regions, the results can be summarized by examining the relationship between adverse events and infrastructure development in an active war theater; emphasis was on predicting the occurrence of events and assessing the potential impact of regional infrastructure development efforts on reducing number of such events.

Throughout my work, two special people have always been there during those years of hard times. This dissertation is dedicated to my parents, Ayşe and Şükrü Çakıt, for their endless love, support and encouragement.

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ANA	Afghan National Army
ANFIS	Adaptive Neuro-Fuzzy Inference Systems
ANNs	Artificial Neural Networks
ASFF	Afghan Security Forces Fund
AUMF	Authorization for Use of Military Force
BNNs	Biological Neural Networks
COA	Centroid of Area
DoD	Department of Defense
FCM	Fuzzy C-Means
FIS	Fuzzy Inference Systems
GIS	Geographic Information Systems
HSCB	Human Social Culture Behavior
ISAF	International Security Assistance Force
IW	Irregular Warfare
LPA	Linguistic Pattern Analyzer
MAE	Mean Absolute Error
MATLAB	Matrix Laboratory
TRAQ-M	Tracking Analysis, Quantification-Mitigation
TSK	Takagi-Sugeno-Kang
UN	United Nations
USAID	United States Agency for International Development

CHAPTER I: INTRODUCTION

1.1 From War to Nation-Building in Afghanistan

Afghanistan lies in the Central Asia and divided into 34 provinces and these provinces are subdivided into 400 districts (Figure 1). It has borders with Pakistan, Iran, Turkmenistan, Uzbekistan, Tajikistan and China. Afghanistan has 647,500 square kilometers and it is somewhat smaller than Texas. The population is approximately 30 million. Based on the United Nations (UN) Human Development Index, that index is calculated according to the health, education, and economic life of people, Afghanistan has been ranked 175th out of 185 members states of the UN (The 2013 Human Development Report). The Afghanistan geography does not land itself to trade, military, and operations. Therefore, this situation makes it difficult to secure the population and to improve their economic situation.

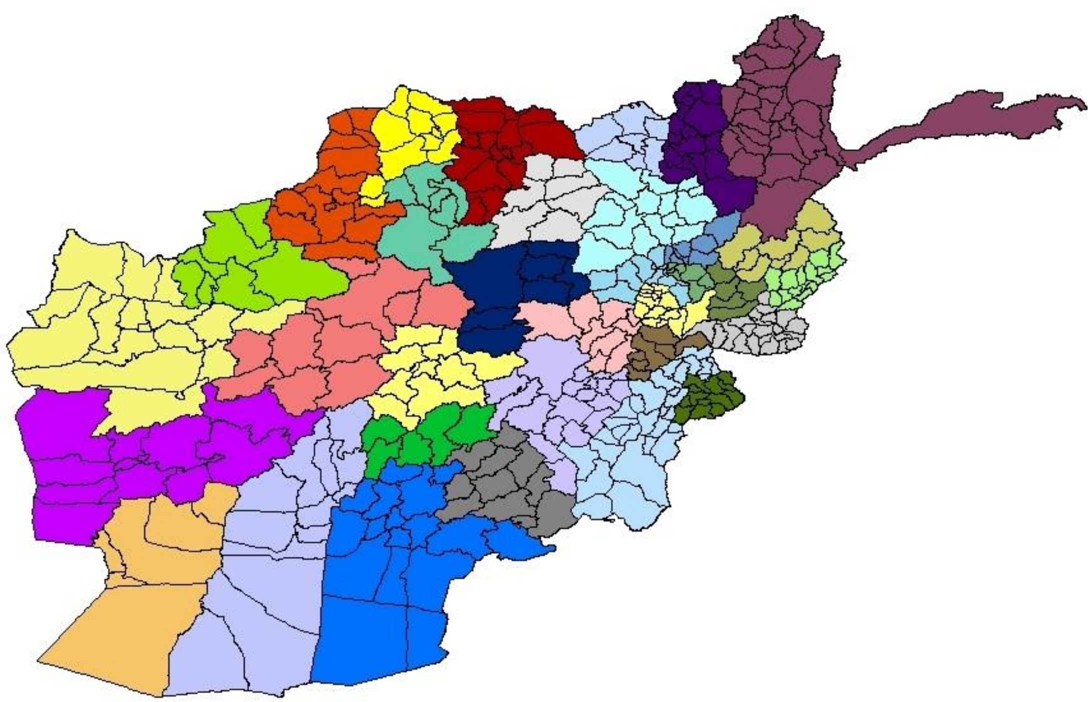


Figure 1: A map of the districts which are color grouped by province

On September 11, 2001, four passenger airliners were hijacked and the planes were crashed into the World Trade Center and the Pentagon. Approximately three thousand innocent people from 90 countries died in the attacks. Although Afghanistan is the main country for al-Qaeda, all nineteen hijackers were from other nations. After one week later, U.S. government signed the Authorization for Use of Military Force (AUMF) against those responsible for attacking the U.S. on 9/11. The U.S. military attacks began on October 7, 2001 against Taliban forces. On November 14, 2001, the UN Security Council approved a resolution for authorizing a temporary administration and asking for member states to send peacekeeping forces to encourage steadiness and aid delivery. In the following year, the first major ground assault and the largest operation Anaconda was launched against al-Qaeda and Taliban fighters. Approximately two thousand U.S. and one thousand Afghan troops joined in this operation. In April 2002, to make Afghanistan as a better place, the U.S. Congress approved over $38 billion in humanitarian and reconstruction assistance to Afghanistan from 2001 to 2009. The milestones of U.S. War in Afghanistan are summarized in Table 1.

In Early 2002, the Afghan government built their army called Afghan National Army (ANA) with a target of 70,000 troops with the help of U.S. Moreover, the International Security Assistance Force (ISAF) defended the Kabul region with 4,000 non-U.S. soldiers. The U.S. government had a limited aid for nation-building and around 8,000 U.S. and allied troops mostly based at north of Kabul for conducting counterterrorist operations across the country. The lead nations can be summarized as followings (Collins, 2011):

- The U.S. for the Afghan National Army
- The British for counternarcotic

- The Italians for the Justice sector
- The Germans for police training
- The Japanese for demobilization and reintegration of combatants

Table 1: The milestones of U.S. War in Afghanistan

Date	Milestones
September 11, 2001	9/11 attacks
September 18, 2001	U.S. government signed a law for authorizing the use of force against 9/11 attacks
October 7, 2001	The U.S. military, with British support, begins a bombing campaign against Taliban forces
November 2001	UN invited its members to send peacekeeping forces to encourage steadiness and aid delivery
December 5, 2001	An interim government
December 9, 2001	Taliban regime ended
March 2002	Operation Anaconda, the first major ground assault and the largest operation
April 17, 2002	The U.S. Congress appropriates over $38 billion in humanitarian and reconstruction assistance to Afghanistan from 2001 to 2009.
November 2002	Establishing a reconstruction model
May 1, 2003	'Major combat' over
January 2004	A constitution for Afghanistan
May 23, 2005	Joint declaration: "strengthen U.S.-Afghan ties and help ensure Afghanistan's long-term security, democracy, and prosperity."
July 2006	Violence increased. The number of suicide attacks and bombings increased.
February 17, 2009	Troop increased. New U.S. government announced plans to send seventeen thousand more troops to the war zone.
July 2009	A new strategy focuses on restoring government services and protecting civilians.
November 2010	NATO member countries signed a declaration agreeing to consign full responsibility for security in Afghanistan to Afghan military by the end of 2014.
May 1, 2011	Osama Bin Laden killed
June 22, 2011	A plan was outlined to withdraw thirty-three thousand troops by the summer of 2012.

(Source: Bruno, G. 2009, Aug)

In 2002, the country was socioeconomically among the ten bottom countries and there was no human capital to build on, then the international community promised over $5 billion in aid and started the work of helping to rebuild Afghanistan (Collins, 2011). After 9/11 attacks, the U.S. government signed agreements with the energy-rich countries bordering Afghanistan. The main objectives of these agreements were to increase economic liberalization and attract investments from foreign capital. The total amount of U.S. assistance was categorized into four portions (Tarnoff, 2010). The main portion since 2001 is approximately 56% of the total amount was given to the Afghan Security Forces Fund (ASFF). This portion includes the training of Afghanistan security forces and their equipment.

The second largest amount is composed of economic, social, and political development efforts and it is approximately 31% of total amount. A third portion of assistance, humanitarian aid, mainly implemented through United States Agency for International Development (USAID) and international organizations, constitutes about 4% of total aid since 2001. The last portion of the aid program is counter-narcotics and is approximately 9% of total aid since 2001.

However, nation-building was not so successful from 2001 through August 2009, when the second presidential election occurred. In this period, there was a negative relationship between the number of military forces and safety in Afghanistan, as the number of adverse events tripled between 2002 and 2007 and endured through the summer of 2009 (Kamrany, 2009). However, these economic and reconstruction efforts are part of the irregular warfare missions which are followed by today's military. To support these efforts, the U.S. military has encouraged various programs to understand the effect of social and cultural factors on human behavior especially to the domain of human, social, cultural, and behavioral (HSCB) modeling.

1.2 Human Social Culture Behavior (HSCB) Modeling

Irregular warfare is defined by the Department of Defense (DoD) as "*a violent struggle among state and non-state actors for legitimacy and influence over the relevant population(s)*". Such warfare includes unproportional force to convince and hassle where opposite forces are not huge and effective in their region (Clancy and Crossett, 2007). Conventional military operations focus on opposite armed forces with the aim of influencing the opposite government. On the other hand, the success of irregular warfare operations mostly depends on the safety of civilian population, since the civilian population is at the center of irregular warfare (Figure 2). The military has made some adjustments to its force structure for recognizing the challenges based on irregular warfare. "Irregular warfare depends not just on our military prowess, but also our understanding of such social dynamics as tribal politics, social networks, religious influences, and cultural mores. People, not platforms and advanced technology, will be the key to irregular warfare success. The joint force will need to be patient, persistent, and culturally savvy people to build the local relationships and partnerships essential to executing irregular warfare." (Irregular Warfare Joint Operating Concept, 2007).

When irregular warfare missions are involved, the human, social, and cultural elements should not be omitted to be successful. Bhattacharjee (2007) outlined in the article "Pentagon asks academics for help in understanding its enemies", a new field called "Human Social Culture Behavior (HSCB) modeling", to guide U.S. military for understanding different types of cultures while operating in overseas countries (Drapeau and Mignone, 2007).

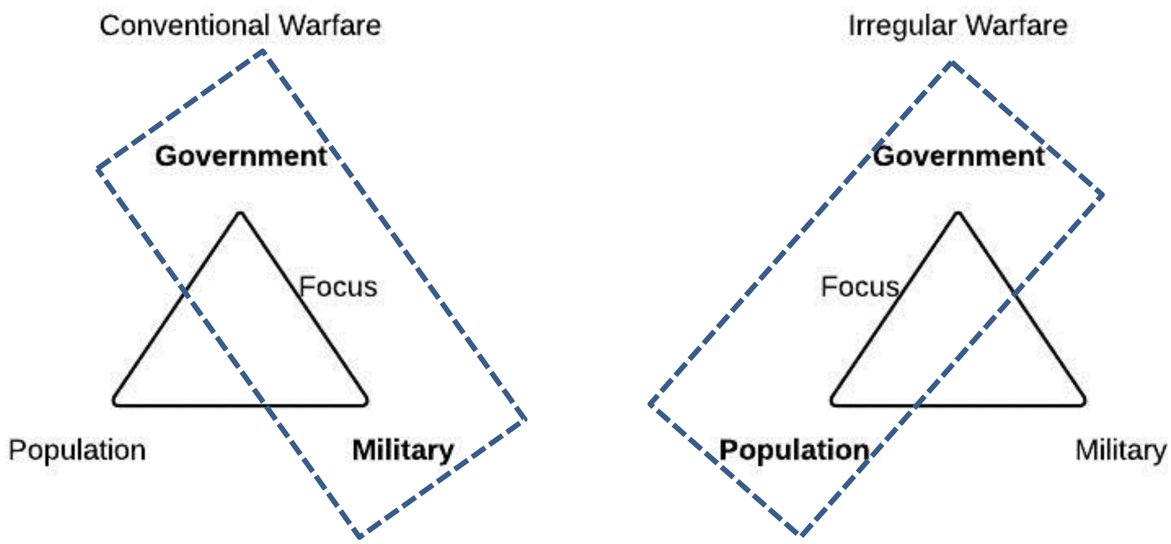


Figure 2: Contrasting Conventional and Irregular Warfare

(Source: Irregular Warfare Joint Operating Concept, 2007)

The overarching aim of the HSCB Modeling is to enable DoD and the U.S. Government to better organize and control the human terrain during nonconventional warfare and other missions (HSCB Modeling Program Newsletter, 2009). The military lately recognized the importance of sociocultural factors into consideration. These factors have been summarized by (Pool, 2011):

- Being respectful and sensitive to local people.
- Understanding local culture, custom, and their history deeply.
- Being capable in communicating with their language at least introductory level.
- Understanding the tribal nature and their leaders.

Therefore, HSCB models are getting much attention in current and future operational requirements to be successful in understanding the effects of social and cultural factors on human behavior. HSCB models are formed in order to understand the behavior and structure of organizational units in macro level (economies, politics, socio-cultural regions) and micro level (terrorist networks, tribes, military units) (Stanton, 2007). There are different kinds of modeling approaches to the data that are being used in this field, and so far none of them has widely been accepted. Since HSCB modeling needs capability for representing complex, ill-defined, and imprecise concepts, soft computing modeling can deal with these concepts. Computational social scientists are researching how observations of human behavior might be used to develop scientifically based models of HSCB events (Schmorrow and Nicholson, 2011). Several studies have employed spatial and temporal analysis to analyze only adverse events; moreover, these studies identify clusters using Geographic Information Systems (GIS). This study investigates the applications of soft computing techniques including fuzzy inference systems (FIS), artificial neural networks (ANNs), and adaptive neuro-fuzzy inference systems (ANFIS) that directly benefits from their accuracy in prediction applications to examine the relationship between adverse events and infrastructure development projects in an active war theater.

1.3 Problem Statement

The prevention of adverse events is challenging in an active war theater. There have been studies by several authors that call for more pattern detection of adverse events. However, sociocultural data integrated with adverse events has not been addressed. In order to be able to understand the relationship between adverse events and infrastructure development in an active war theater, it is important that a study based on soft computing techniques be conducted to assess the effects of infrastructure development on occurrence of adverse events and examine the differences in adverse event outcomes due to infrastructure development over time.

1.4 Research Gap

Since GIS can provide crucial information about the spatial patterns of terrorist based data, recent publications by several authors call for more pattern analysis of terrorist incidents using GIS. (LaFree at al., 2011; Berrebi and Lakdawalla, 2007; Siebeneck et al., 2009; Brown et al., 2004; Johnson and Braitwaite, 2009; Webb and Cutter, 2009). Based on the current literature, there are only two studies that have applied computational techniques to the dataset related to adverse events (Inyaem et al., 2010; Minu et al.,2010). There are currently no studies on the use of any computational methodology for representing the relationship between adverse events and infrastructure development investments in an active war theater.

1.5 Research Objectives

The main objective of this study is to investigate the relationship between adverse events and infrastructure development in an active war theater using soft computing techniques. This study has two specific objectives. The first objective is to predict the occurence of adverse events in different regions of Afghanistan. The second objective is to assess the potential impact of regional infrastructure development efforts on occurence of adverse events.

1.6 Research Questions

The main questions addressed by this research are follows:

1) Does infrastructural development affect the occurrence of adverse events?

2) Are there any differences in adverse event outcomes due to infrastructure development over time?

1.7 Study Design

Since one of the main goals is to investigate the relationship between adverse events and infrastructure development, integrated data of adverse events and infrastructure development were analyzed using soft computing techniques to make overall conclusions for predicting the occurance of adverse events in terms of the number of people killed, wounded, hijacked, and total number of adverse events under infrastructure effect.

This study was conducted based on the following sequence of main steps as shown in Figure 3:

Step 1: Data migration to include a single database representing the variables of adverse event numbers (number of people killed, wounded, hijacked, and total number of adverse events) in "Witsgeo" data, project budgets and aid number in "USAid" data and population information in "AISCS" data are considered in this study. The population density is available only for year 2008.

Step 2: Input and output selection to represent the variables for infrastructure development, population density and adverse events.

Step 3: Represent data on district and monthly bases for the years 2004-2009 (for model training), and year 2010 (for model testing).

Step 4: Divide the data into seven regions for regional analysis.

Step 5: Perform prediction accuracy by using Mean Absolute Error (MAE).

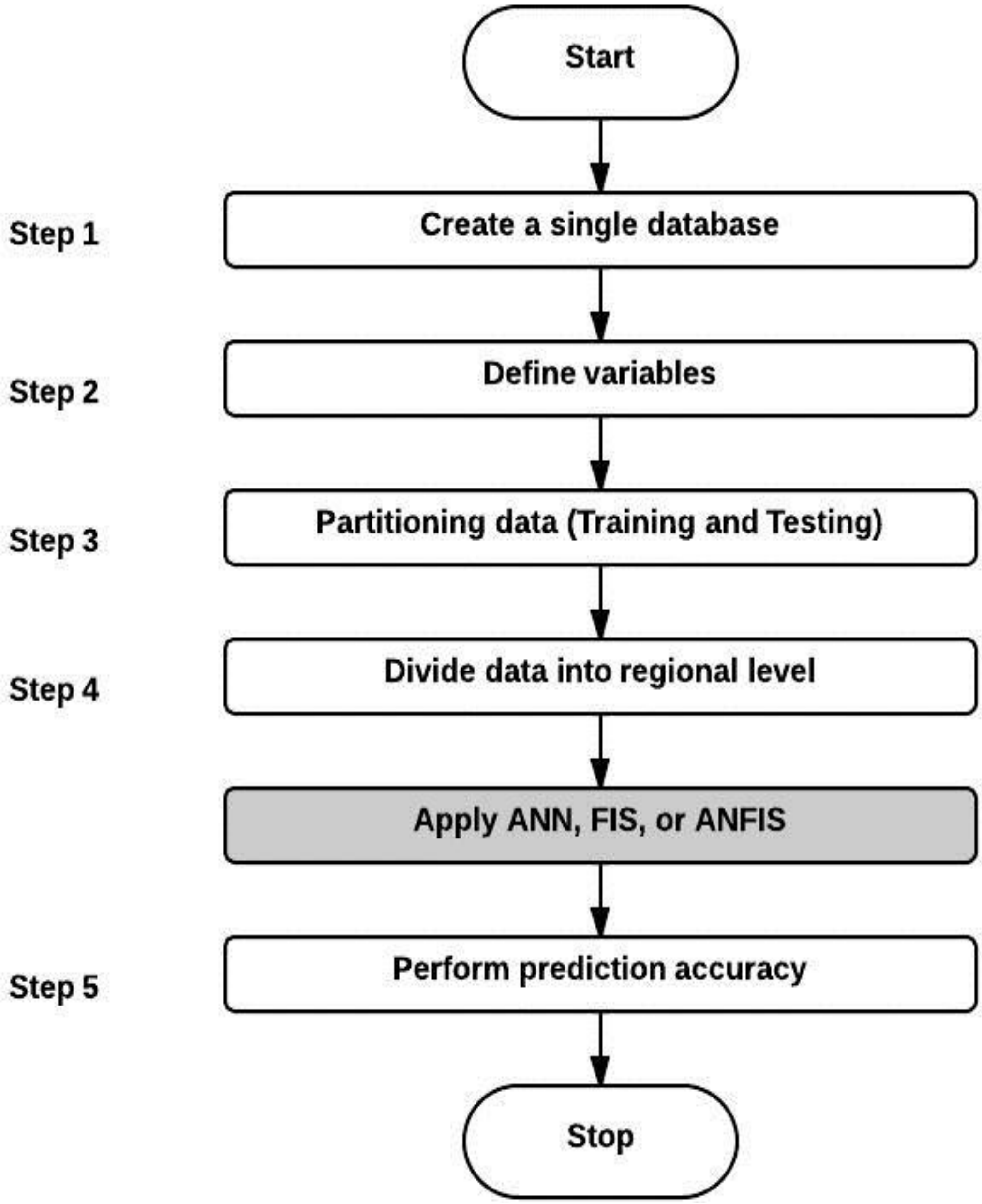


Figure 3: Common steps for all three methodologies

CHAPTER II: LITERATURE REVIEW

2.1 Challenges and General Modeling Approaches

There are various challenges associated with problems related to representing social science data. Some of these challenges have been highlighted by other researchers. For instance, technical and managerial challenges in HSCB modeling were summarized by Numrich and Tolk (2010) as lack of common vocabulary, variations in modeling approaches, and data acquisition. Garrett et al. (2009) discussed the importance of creating a virtual enterprise of networked HSCB professionals for effective collaboration. Since each discipline may differ generally in methodology associated with HSCB events, they addressed this challenge such as mapping information to a global visualization tool. Tolk et al. (2010) summarized the position of papers by inviting five internationally recognized people in the field of HSCB to get their ideas for the argument on methodological approaches to meet the difficulties in HSCB modeling. Tolk (2009) highlighted the changing tasks that require “whole of society” approach for focusing on HSCB modeling. A requirement for the framework to identify applicable models and methods and listing them was stressed as a result. Schmorrow et al. (2009) emphasized the challenge of leveraging Modeling and Simulation (M&S) for HSCB. They stated the difficulty in understanding which M&S tools are actually useful and when and how best to use these M&S tools within different complexity levels. Sims and Taylor (2009) aimed to provide “plug and play cultural avatars” that can be imported into training environments being used by the DoD. For this purpose, they developed for the visual cues to perform successful interviews, rapport building, and negotiations. West (2008) presented concepts and issues in HSCB modeling for Stability, Security, Transition and Reconstruction Operations (SSTRO) which is a key policy initiative that permeates all agencies and levels within the DoD. Numrick (2010) aimed to deconstruct the problem of fitting HSCB data simulations into several steps, starting with the vocabularies in which they begin to express the problem space and concluding with a brief review of two architectures. The author concluded that the potential use for unifying architectures is to provide researchers and practitioners an environment in which to explore. Recently, Hahn (2013) highlighted the challenges in verification and validation of HSCB models by reviewing the literature. The author concluded that empirically-based models are not often applicable for validation of HSCB models. All these challenges stated by these researchers must be understood and research should meet specific modeling requirements before proceeding to apply various methodologies in the social science and HSCB field.

2.2 Spatial Statistics

Models of human behavior could be used to predict the effects of actions intended to disrupt terrorist networks. These groups of studies emerge from data-driven, statistical approaches where the modeler empirically derives the HSCB model from patterns identified in the data (Zacharias et al., 2008).Since terrorist attacks are not random in space and time, there are patterns that exist. It is likely to detect representative patterns in terrorist activity by considering geospatial intelligence on adverse events, based on the Director of National Intelligence Open Source Center (Federation of American Scientists, 2009).

The Open Source Center (OSC) (2009, April 30) study of terrorism in Afghanistan highlighted various types of analysis that include spatial patterns and an assessment of adverse events that would be helpful to those interested in the dynamics of Afghanistan's security, especially those analyses included in that work are as follows:

- mapping incident density
- identifying the dominant ethnic group where incidents occurred
- mapping incidents by district, mapping incidents by province
- identifying the mean center of incidents over time
- calculating the standard deviation (spatial pattern/trend) of overall incidents
- mapping total incidents by month
- computing the mean center of incidents by month

The work of spatial and temporal analysis of terrorist attacks is becoming important in the literature. Thus, spatial and temporal analyses have been used by several authors to analyze patterns. Recently, LaFree et al. (2011) examined geographic characteristics of all terrorist attacks attributed to the Spanish group ETA from 1970 to 2007. They considered how the approaches of terrorist groups may have relation with their geospatial attack patterns over time. Berrebi and Lakdawalla (2007) considered how terrorists sought targets and focused on the spatial and temporal determinants of terrorism in Israel between 1949 and 2004. Based on the analysis, they found that space and time are necessary to describe the patterns of terrorism in Israel. They concluded a pattern where regions that experience attacks are more on the spot to attack in the following 8 weeks.

Similarly, Siebeneck et al. (2009) used historical data from 2004 to 2006 and developed a series of analyses to understand terrorist activity spaces and counter terrorist actions. They focused on terrorist incidents in Iraq in order to detect patterns. They applied several spatial and temporal statistical and clustering approaches as well as GIS to provide knowledge about patterns.

Brown et al. (2004) highlighted a specific event called suicide bombings for representing difficulties in understanding and preventing terrorist attacks. They proposed a fusion model which is the combination of spatial likelihood modeling of environmental characteristics and logistic regression modeling of demographic features. They concluded that the fusion model shows better performance than other methods such as kernel density estimation methods. Johnson and Braitwaite (2009) highlighted the space-time clusters of Improvised Explosive Device (IED) and non-IED attacks in Iraq from January to June of 2005.

Webb and Cutter (2009) described trend in terrorist incidents with respect to space and time in the United States spanning the years 1970 through 2004. In this paper, the authors applied a descriptive spatial analysis to argue the temporal and spatial patterns of terrorist events in the U.S getting some interest to the specific characteristics such as attack types, target types, weapon types, and group or perpetrator types.

As a prediction approach among terrorist based data, Reed et al. (2011) aimed to demonstrate a proof of concept that a statistical understanding of terrorists' behaviors could be used to predict patterns in future behaviors. They applied time-correlation based prediction approach and identified trends in behaviors of terrorists. They concluded that these trends could be used for prediction future attacks and it might help decision-makers to allocate more resources and personnel to the place which are more likely to be attacked.

A hot spot is described as a region that has more than average number of criminal or adverse events, or an area where community have a higher than average risk of victimization

(Eck et al., 2005). Paynich and Hill (2010) defines hot spot analysis as : "A hot spot analysis is just the start of any good crime analysis effort and can be used to find single event hot spots at which to address enforcement or to track progress of a tactical action plan over time." Hot-spot analysis has been accepted as a useful technique in crime research domain which can be useful also in micro HSCB area with incident research. There are various software tools that have the ability to perform many of hot-spot analysis such as ArcGIS and CrimeStat (free). Hot-spot analysis can be used for calculation the difference in expected incidents versus observed incidents. Furthermore, it can be used for identifying incident hot-spots, as well as in identifying emergent and evolution patterns of hot-spots over time (Siebeneck et al., 2009).

2.3 Soft Computing Techniques and Applications

Fuzzy inference systems and artificial neural networks are both very demanding soft computing techniques for modeling the behavior of an expert (Zadeh, 1994a). The main goal is to mimic the actions of an expert who solves complex problems (Nauck et al., 1997). Fuzzy inference systems, artificial neural networks, and neuro-fuzzy models can be applied independently as well as jointly depending on the type of the domain of applications. For instance, Inyaem et al. (2010) applied fuzzy inference systems (FISs) for event classification in the domain of adverse incident analysis. They presented a comparison of these frameworks of classification using FISs with structured and unstructured events, and a comparison of structured event frameworks of classification using FIS and adaptive neuro-fuzzy inference systems (ANFIS) in incident monitoring domain. They concluded ANFIS gives better performance than FIS for event classification. Minu et al. (2010) analyzed the time series of number of terrorist attacks in the world measured on monthly basis from 1968 to 2007. They concluded that Wavelet Neural Networks provides the best model to analyze the terrorist attacks time series over existing methods. Elkosantini and Gien (2007) proposed a model that has two phases; the first one represented human behavior in a physiological and behavioral aspect, the second one integrated the sociological aspect. They applied fuzzy sets and fuzzy inference system to describe the model and noted that the described model can be implemented in an agent-based approach.

2.3.1 Fuzzy Clustering

When the number of event-points is high, the classical density methods are not appropriate to determine the impact areas because of high computational complexity; then the usage of cluster algorithms seems more suitable: it is well known that the clusters contain similar data and the degree of association is weak between data of different clusters (Martino and Sessa, 2009). In spatial data in clustering, different kinds of clustering algorithms have been applied, "including spatial clustering (clustering of spatial points), regionalization (clustering with geographic contiguity constraints) and point pattern analysis (hot-spot detection with spatial scan statistics) and the use of many of these techniques for hot-spot detection is relatively problematic for several reasons, including the relatively arbitrary definition of the number of clusters to be included and the procedures applied to draw hot-spot boundaries" (López-Caloca and Reyes, 2012). A fuzzy clustering algorithm allows data points to be part of several clusters concurrently with different degrees of membership. Thus, fuzzy clustering algorithms are useful for the determination of hotspots in crime analysis. For example, Grubesic., T.H. (2006) presented an empirical analysis on the benefits of fuzzy cluster analysis for crime hot-spot detection. The results show that fuzzy clustering is useful approach for dealing with intermediate points and spatial outliers while comparing with other traditional approaches utilized in spatial applications. Martino et al. (2008) have implemented the extended fuzzy C-means (EFCM) method in a GIS environment developed with the tool ESRI/ARCGIS. They showed that the extended fuzzy C-means (EFCM) algorithm works better than the classical FCM algorithm: indeed it determines automatically the initial number of clusters, it prevents the problem of shifting the clusters with low density area of data points in areas with higher density of such points and it finds the cluster volume prototypes as hyperspheres.

2.4 Application of Crime Pattern Detection Techniques

Techniques applied for detecting, monitoring, and estimation of spatial patterns for crime analyses may be beneficial in conducting studies of adverse event data. Because of the fact that adverse incidents are still crimes and target selection for both incident data and crime data are not random in space and time. In the specific case of crime prediction, semantic data for identifying the incidents is highly acceptable, as it is necessary to support decision making processes and, in general, to prevent and correct policies (Kumar and Chandrasekar, 2011) . Liu and Brown (2003) applied point-pattern methods of geography to forecasting as one of the first applications in literature. This methodology has been described as a newly created space-time prediction model for crime points. They conclude that their model outperforms the best of current ‘‘hot spot’’ methods. Corcoran et al. (2003) demonstrated the training of artificial neural networks by using geographical clusters of crime data to simplify predictive modeling. Gorr et al. (2003) studied monthly crime data from 1991 to 1998. They compared forecast accuracy of naive methods widely used by police and they found the most accurate forecast model to be the Holt exponential smoothing approach for precinct-level crime series. Polat (2007) generated a model that predicts crime patterns by applying time series forecasting approach with the help of GIS. The proposed model provided information for police departments in both space and time.

Kumar and Chandrasekar (2011) applied a spatial-temporal prediction model to predict the criminal activity behavior in a particular district by using structured crime classification algorithm.

2.5 Agent-Based Approaches

Agent-based modeling is the computational study of complex systems that seek to use system dynamics, social network analysis, probabilistic reasoning, and game theory for better decision making (Zacharias et al., 2008). Recently, Jiang et al. (2012) highlighted the importance of Agent-based modeling and simulation (ABMS) applications in the domain of human socio-cultural behavior (HSCB). They concluded that ABMS has advantages and it is increasingly being used in HSCB field. However, some limitations exist in using these methodologies in this area. These methods have shown particular promise for implementing HSCB models with large data set because these approaches need large amounts of data, and the results can be difficult to explain (Schmorrow and Nicholson, 2011). Additionally, it is stated that these models are not successful for providing the adaptability and learning they have aimed to satisfy. As an alternative to the agent-based modeling, Barber and Nicholson (2009) proposed a hybrid approach called Intelligent Resource Operational Network (IRON) framework for developing human, social, and cultural behavior models. They attempted to combine machine learning approaches such as rule-based systems, artificial neural networks, genetic algorithms, and cognitive methods, etc.

The cultural geography model is defined as “an agent-based model of the operational environment based on doctrine and social theory designed to address the behavioral response of civilian populations in conflict environments” (Alt et al., 2009b). Hudak and Baez (2010) aimed to determine the impact of operations on the populace over time by providing an overview of the application of an agent-based model called “Cultural Geography” to represent the civilian populace. The environment for this particular application includes six districts within Helmand province, Afghanistan. The specific results based on analysis of the scenarios by district and population group revealed that the most significant positive impact on the population’s perception of security, infrastructure, and governance was directly related to the amount of non-kinetic operations. Similarly, Alt et al. (2009a, 2009b) presented an overview of a cultural geography agent-based modeling framework based on the human behavioral and social theory to represent populations’ viewpoint as a function of their beliefs, values and interests.

McFate and Jackson (2005) defined "human terrain" as “the human population and society in an environment of interest (area of military operations) characterized by sociocultural, anthropologic, and ethnographic data and other non-geophysical information about that human population and society.” Silverman (2007) highlighted the usage of “human terrain” datasets which are “a key asset for those interested in synthesis of two major agent-based modeling paradigms called the cognitive and the social.” They pursued with a case study that integrates a cognitive and a social agent environment and applied them to various regions of interest to assess their validity.

2.6 Linguistic Pattern Analysis

The TRAQ-M (Tracking Analysis, Quantification-Mitigation) platform is a computational system and one of the first in a new class of software for understanding complex human behavior patterns. As a component of TRAQ-M, Linguistic Pattern Analyzer (LPA) is applied for information extraction and collects "hits" and counts the content in the study which is directly related to indicators of some computational social sciences models (Mack et al., 2007). For instance, Russell and Clark (2009) discussed "the underpinnings of the Linguistic Pattern Analyzer (LPA) designed as a platform to instantiate HSCB models, extract and measure HSCB inputs, and produce assessments automatically." They concluded this study illustrating how one conceptual HSCB model was automated through combining human expertise, metrics, and the LPA.

CHAPTER III: METHODOLOGY

3.1 Soft-Computing Techniques

In real world applications, there are many problems which could be solved theoretically instead of analytically. However, it is actually not possible to solve some problems theoretically due to their complexity, uncertainty, and necessity of massive time required for computation. For these kinds of problems, methods inspired by nature usually work very efficiently and effectively. Although the solutions captured by these methods do not always have same solutions with the mathematically strict ones, an approximate optimal solution is sometimes enough for most practical applications. These biologically inspired methods are called soft computing.

The term "Soft Computing" was defined by Zadeh (1994): "Basically, soft computing is not a homogeneous body of concepts and techniques. Rather, it is a partnership of distinct methods that in one way or another conform to its guiding principle. At this juncture, the dominant aim of soft computing is to exploit the tolerance for imprecision, uncertainty, partial truth, and approximation to achieve tractability, robustness, and low solution cost. The principal constituents of soft computing are fuzzy logic, neurocomputing, and probabilistic reasoning, with the latter subsuming genetic algorithms, belief networks, chaotic systems, and parts of learning theory. In the partnership of fuzzy logic, neurocomputing, and probabilistic reasoning, fuzzy logic is mainly concerned with imprecision and approximate reasoning; neurocomputing with learning and curve-fitting; and probabilistic reasoning with uncertainty and belief propagation."

Soft computing techniques basically use numerical data that characterize input-output relationships that support decision making. With these kinds of techniques it is possible to handle imprecision, uncertainty, and complexity in data. These techniques are usually preferred while other traditional approaches may not produce acceptable predicted results. Furthermore, these techniques have some attributes that allow identifying cause and affect relationships in terms of verbal statements and if-then rules. The main elements of soft computing are fuzzy inference systems (FIS), evolutionary computation including genetic algorithms, artificial neural networks (ANNs), machine learning, and probabilistic reasoning (Figure 4).

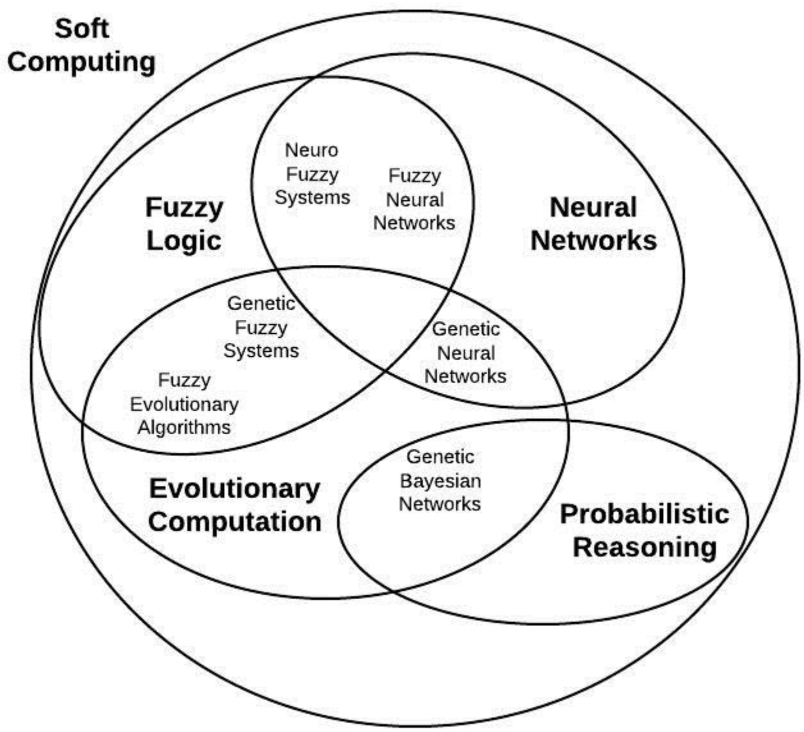


Figure 4: Hybrid approaches and the main components of Soft Computing

(Adapted from Cordon et al., 2001)

General model framework used in this research is illustrated in Figure 5. For this research, we applied (i) ANNs, (ii) FIS using fuzzy c-means (FCM) and subtractive clustering algorithms, and

(iii) adaptive neuro-fuzzy inference systems (ANFIS) as three representative methods of Soft Computing that directly benefits from their accuracy in clustering and prediction applications. These three approaches will be explained in the following sections.

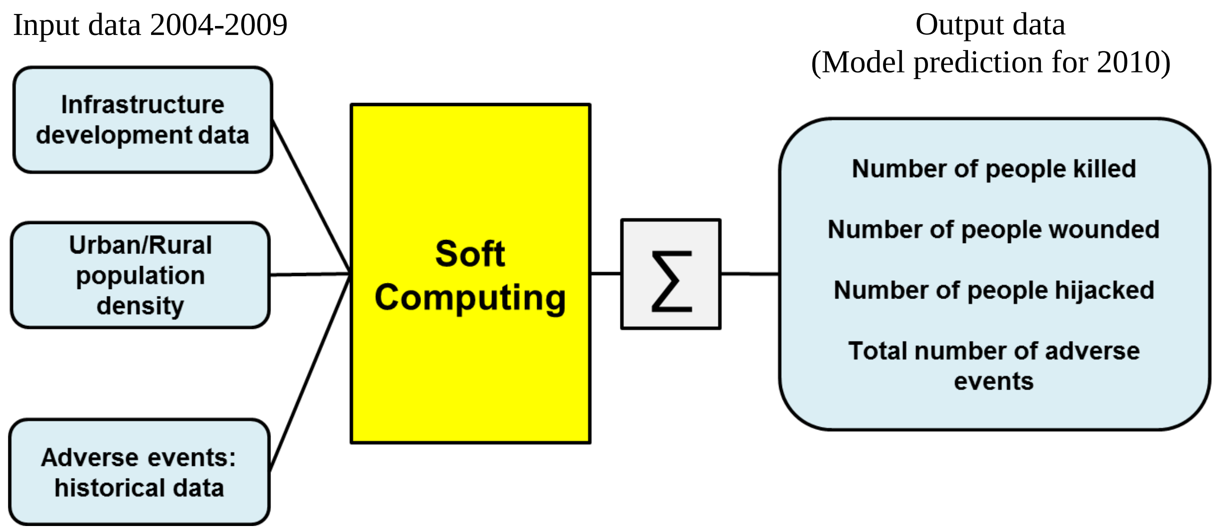


Figure 5: General model framework used in this research

3.1.1 Artificial Neural Networks

Artificial neural networks (ANNs) (Figure 6) are mathematical models of the human brain which mimics the functioning mechanism of biological neural networks.

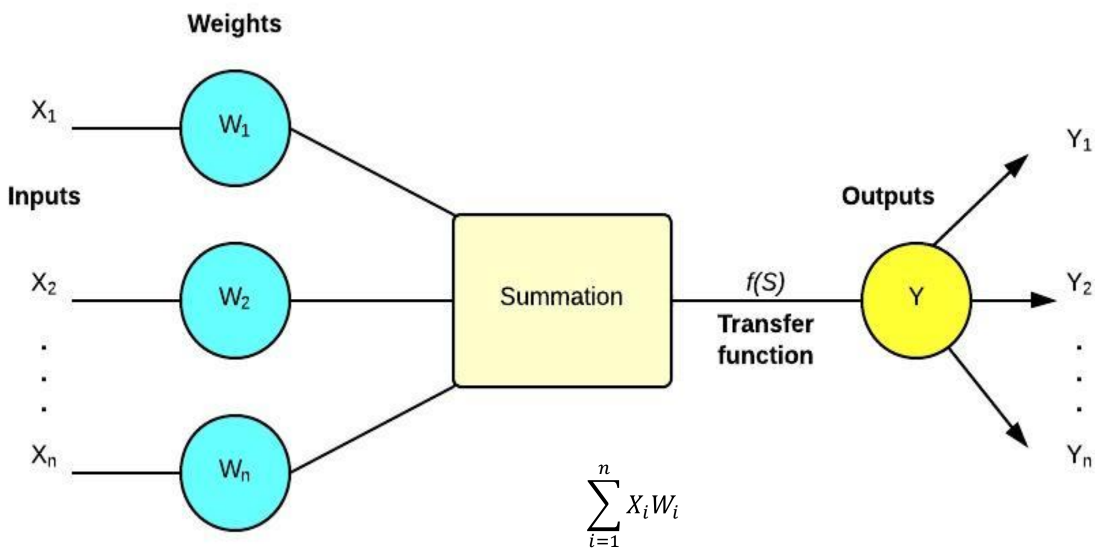


Figure 6: Illustration of an artificial neural network

The brain has approximately 10^{11} highly interconnected network of neurons, which communicate by sending electrical signals through the neural wiring includes axons, synapses and dendrites. There are similarities between the components of ANNs and biological neural networks (BNNs) as summarized in Table 2. As stated in the illustration of ANNs, weighted-summation input and a nonlinear output activation function constitute a processing element (neuron) which is defined as a nonlinear mathematical model that sums the product of each input and its connection weight (Zurada et al. 1997).

The weight of an artificial neuron gives an idea of how strong the related input is. There is a learning/training unit where the weights are updated. There is also a bias unit and the sum is transformed using the activation function *f*.

Table 2: Similarities between the components of ANNs and BNNs

Biological NN	**Artificial NN**
neuron	node
dendrites	input
axon	output
synapse	weight

The milestone works for ANNs are as follows:

- *McCulloch and Pitts (1943):* The earliest work on neural networks began and they introduced the first computational model of a neuron.
- *Hebb (1949):* The first learning rule is proposed.
- *Rosenblatt (1958):* A perceptron network is built and he illustrated its ability to perform pattern recognition.
- *Minsky and Papert (1969):* They demonstrated that a perceptron network could solve only small number of problems.
- *1970s:* ANN research became less active.
- *1980–90s:* ANNs return with the back-propagation algorithm for training multilayer perceptron networks.

3.1.1.1 The Architecture of ANNs

According to the network architecture type, ANNs can be classified into two classes:

- Feed-forward networks (no loops)

* Recurrent (feedback) networks (loops exist)

Several network architectures are illustrated in Figure 7.

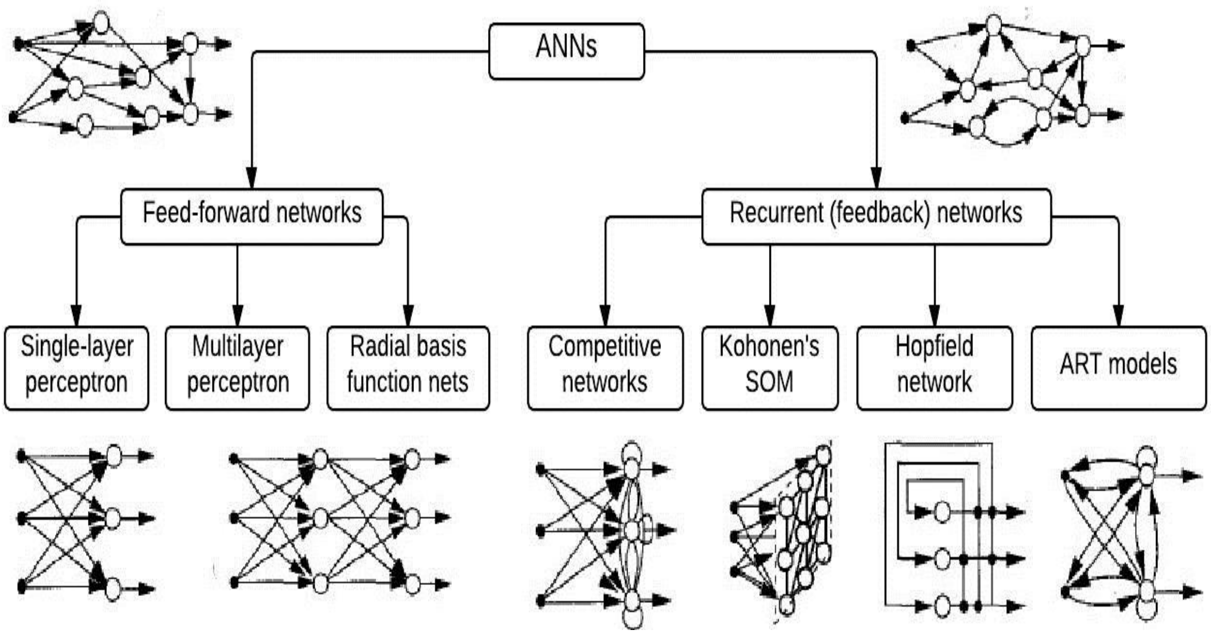


Figure 7: ANN architectures for each category

(Source: Jain et al., 1996)

Learning ability is the basic characteristics of ANNs. ANN learning process can be defined as the updating network architecture and the weights. There are basically two types of learning in ANNs: supervised and unsupervised. In supervised learning, the training is under control. However, unsupervised learning do not need any external agent to control training. ANN learning process has three basic steps (Figure 8):

* Compute outputs
* Compare predicted outputs with actual outputs
* Adjust weights if necessary and repeat this process until ending with satisfactory results

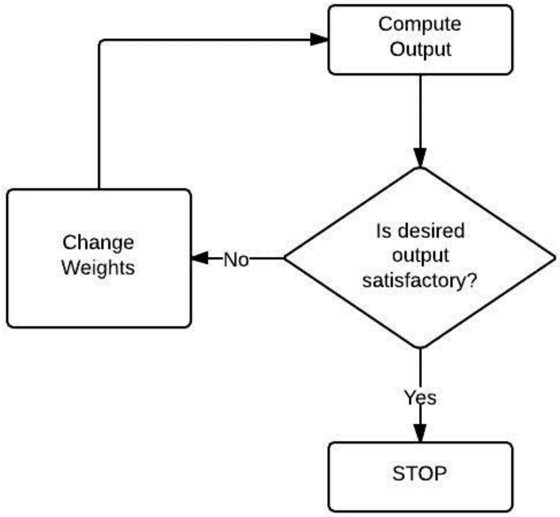


Figure 8: ANN learning process

Feedforward Multilayer Perceptron which is a type of supervised learning was applied in this research. Feedforward MLP neural network modeling has supervised learning algorithm which helps to learn from training data by using input-output pairs. The performance of unknown data, which has not shown to the model before, is used to represent how accurate the mapping is between input and output values. MLP with three kinds of layers called input, output, and a hidden layer are illustrated in Figure 9. Neurons in input layer distributes the input signals X_i (i=1, 2 …n) to neurons in the hidden layer.

Each neuron j in the hidden layer aggregates its input signals X_i after weighting them with the weights of the corresponding connections W_{ji} from the input layer and calculates its output y_j as a function f of the sum (Equation 1).

$$y_j = f\left(\sum_{i=1}^{n} W_{ji} X_i\right) \qquad (1)$$

Where: f can be different functions such as simple threshold function and hyperbolic tangent, function.

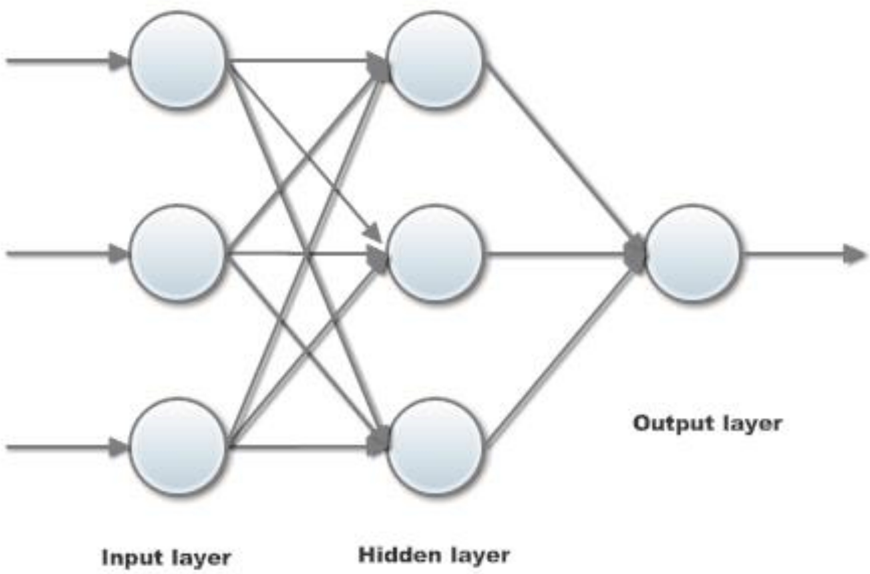


Figure 9: Architecture of a feed-forward multilayered neural network

There is a similarity in the calculation of the output values for the output layer. The back propagation algorithm is used frequently among MLP training algorithms. It gives ΔW_{ji} weight change of a connection between neurons i and j (Equation 2):

$$\Delta W_{ij} = \mu \delta_j X_i \quad (2)$$

Where: μ is a learning rate and δ_j is a factor where neuron j is an input or a hidden neuron.

For output neurons,

$$\delta_j = \left(\partial \mathrm{f} / \partial \mathrm{net}_j\right)\left(y_j^{(t)} - y_j\right) \quad (3)$$

For hidden neurons,

$$\delta_j = (\partial \mathrm{f}/\partial \mathrm{net}_j)(\textstyle\sum_q w_{jq}\delta_q) \qquad (4)$$

Net_j : total weighted sum of input values to neurons j

$y_j^{(t)}$: desired output for neuron j

Since there is no desired output for hidden neurons, $y_j^{(t)} - y_j$ (desired – actual values) (Equation 3) is replaced with $\sum_q w_{jq}\delta_q$ (weighted sum of the δ_q) (Equation 4). The δ term is calculated for all and weights are updated repetitively. After introducing all training sets, weight is updated. Number of training epoch depends on the number of training patterns introduced to the MLP (Al Shamisi et al., 2011).

3.1.1.2 Network Training Algorithm

ANN architectures were discussed in previous section. They all need applicable training algorithms. MLP is trained using the momentum and Levenberg–Marquardt (LM) learning algorithms. The network was assigned with random weights and trained with Levenberg-Marguardt algorithm for this research. The Levenberg–Marquardt (LM) algorithm, classified as higher-order adaptive algorithms, is good for decreasing the mean square error (MSE). LM algorithm has an important advantage, which "it defaults to the gradient search when the local curvature of the performance surface deviates from a parabola", which is so common in neural network approaches (NeuroSolutions documentation). This algorithm can be summarized as follows (Equation 5):

$$X_{n+1} = X_n - [J^T J + \mu I]^{-1} J^T e \qquad (5)$$

where;

X_n : current weight matrix

X_{n+1} : new weight matrix

e : network error

J: is a Jacobean matrix that contains the 1st derivative of network error with respect to the current weights and biases

I : identity matrix

μ : learning rate

3.1.1.3 Transfer (Activation) functions

The transfer function is also called the activation function is a mathematical illustration of the relation between the input and output variables. The transfer function represents a degree of nonlinearity in ANNs. There are several transfer functions. Two of them used in this research are shown below:

3.1.1.3.1 Log-sigmoid transfer function

This function takes the input value between plus and minus infinity and forces the output into the value between 0 and 1 based on the graph (Figure 10) and the expression (Hagan et al., 1996):

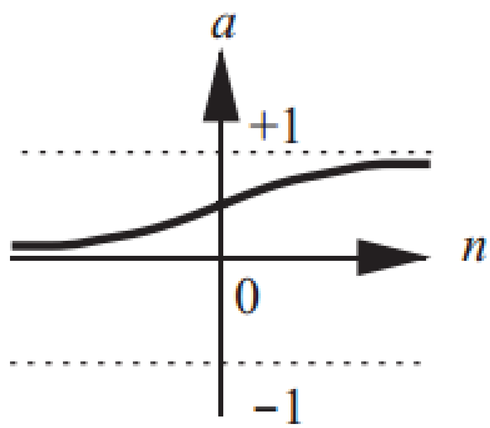


Figure 10: Log-sigmoid transfer function

$$a = \frac{1}{1 + e^{-n}}$$

This transfer function is mostly used in multilayer neural networks which are trained by using the back-propagation algorithm.

3.1.1.3.2 Hyperbolic tangent transfer function

Hyperbolic tangent transfer function (Tan-sigmoid transfer function) is similar to sigmoid function and its range outputs between -1 and +1 as shown in Figure 11.

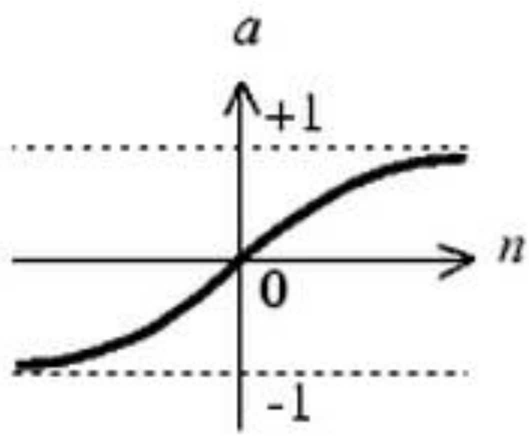


Figure 11: Hyperbolic tangent transfer function

$$a = \frac{e^{n} - e^{-n}}{e^{n} + e^{-n}}$$

3.1.1.4 Data Normalization

Data normalization is necessary where the inputs are in different scales and it is usually occured before training the network. There are several types of data normalization approaches. The selection of ranges for input and output values mostly depends on the type of activation function of output nodes, in generally [0,1] for logistic function and [-1 1] for hyperbolic tangent function (Zhang et al., 1998). Hyperbolic tangent function was selected for output nodes therefore; all data were normalized between -1 and 1 to produce uniformity for ANN models in this work. The network output values need to be rescaled to the original form and the prediction performance accuracy should be calculated based on the converted original dataset form.

```
%Normalizing data
[pn,ps] = mapminmax(P');
[tn,ts] = mapminmax(T');
[an,as] = mapminmax(a');
[sn,ss] = mapminmax(s');

%transform tested data to its original form
anew = mapminmax('reverse',y',ss);
```

Figure 12: MATLAB normalization code

The MATLAB function “mapminmax” was used to scale the input and output values so that they fall in the range [–1, 1]. The code is illustrated in Figure 12.

In summary, ANNs are able to identify complex nonlinear relationships between input and output datasets which perform better than other traditional tools in dealing with problems in several categories such as classification, clustering, function approximation (modeling), prediction, optimization, association, and control (Basheer and Hajmeer, 2000). Many different resources are available in the literature for further explanations on ANNs (Zurada, 1992; Fausett, 1994; Gurney, 1997; Haykin, 1999).

The application of ANNs in this research was conducted according to the sequence of steps as shown in Figure 13.

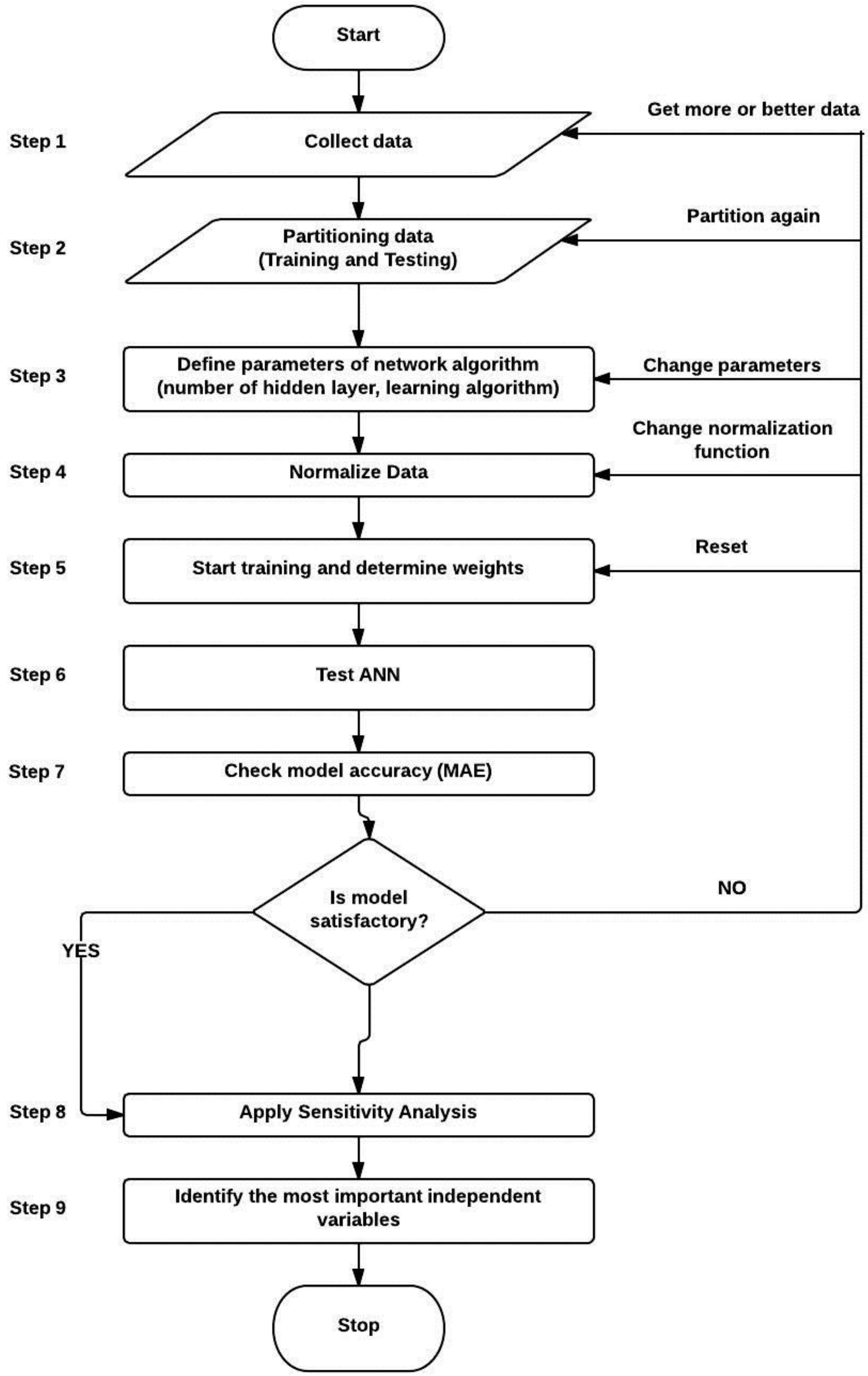


Figure 13: ANN flow diagram used in this study

3.1.2 Fuzzy Sets

An alternative approach to the bi-valued logic of Aristotle was initialized by Lukasiewicz (1920), when he defined a three valued logic which can be converted as the term "possible" and he assigned it an arithmetic value between True and False (Fullér, 1999). The concept of "Fuzzy sets" was initiated by Zadeh (1965) that represent imprecise data and an extension of classical set theory. A fuzzy set is defined by "a function that ranges between 0 and 1, which assigns the degrees of membership to each element in a set" (Ammar and Wright, 2000). Following the first publication in fuzzy set theory by Zadeh (1965), he suggested a linguistic description of human thinking (Zadeh, 1968) and a linguistic approach for modeling complex and ill-defined systems related to fuzzy systems (Zadeh, 1973).

Table 3: Comparison of Fuzzy Sets and Crisp Sets

Fuzzy Sets	**Crisp Sets**
The set *A* can be represented by its membership function: $\mu_A : X \to [0,1]$	The set *A* can be represented by its characteristic function: $m_A : X \to \{0,1\}$

As it is shown in Table 3, in classical set theory the membership of elements in relation to a set is defined as binary terms based on the crisp condition (an element is part of the set or not). On the other hand, fuzzy set theory allows the continuous assessment of the membership of elements in relation to a set; this is represented by the membership function defined in the real unit interval [0, 1]. Therefore, the crisp sets are special cases of fuzzy sets; in other words crisp sets are subsets of fuzzy sets (crisp sets ⊆ fuzzy sets).

3.1.2.1 Membership Functions

As mentioned earlier, a fuzzy set is completely represented by its membership function. Membership functions can be determined by intuition or using some algorithms. The most commonly used membership functions are summarized in Figure 14.

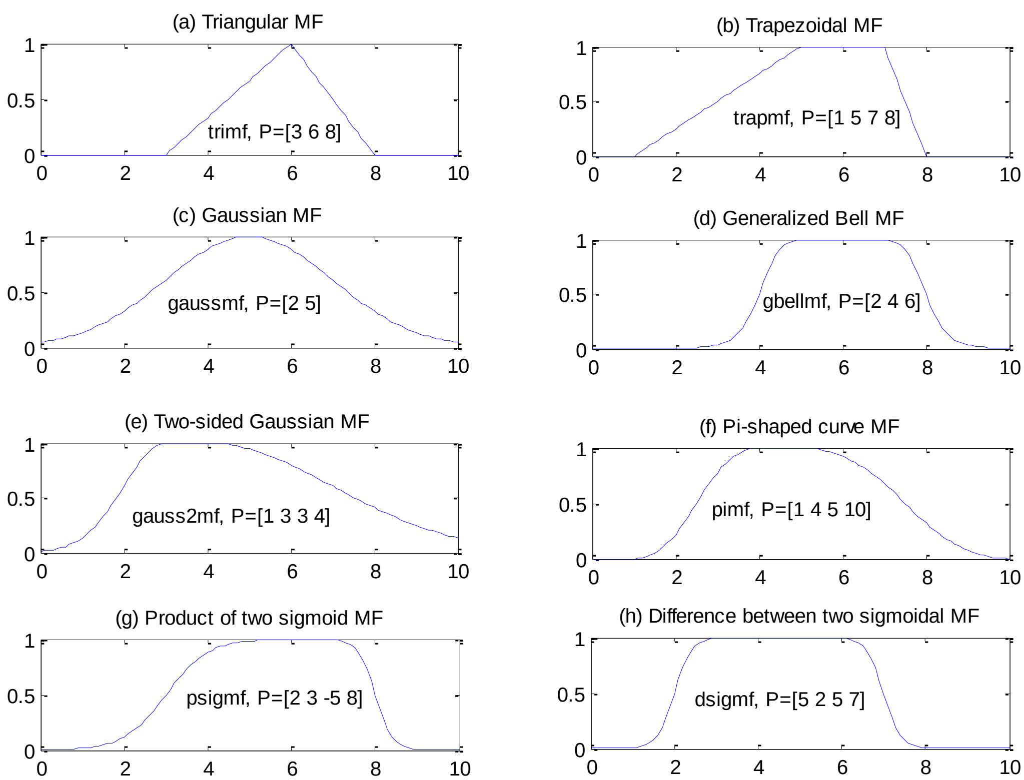


Figure 14: Examples of common membership functions

3.1.2.2 Fuzzy Systems

A fuzzy system consists of five functional blocks including fuzzification, database, rulebase, fuzzy inference systems (inference operations), and defuzzification (Figure 15). Moreover, input and output variables can be included. A fuzzification interface maps real numbers of input into fuzzy sets with linguistic values such as low, medium, high. Each mapping is represented by its membership functions; a fuzzy rule base contains a number of fuzzy if-then rules that include all possible fuzzy relation between input and output values; a database which describes the membership functions of the fuzzy sets used in the fuzzy rules.

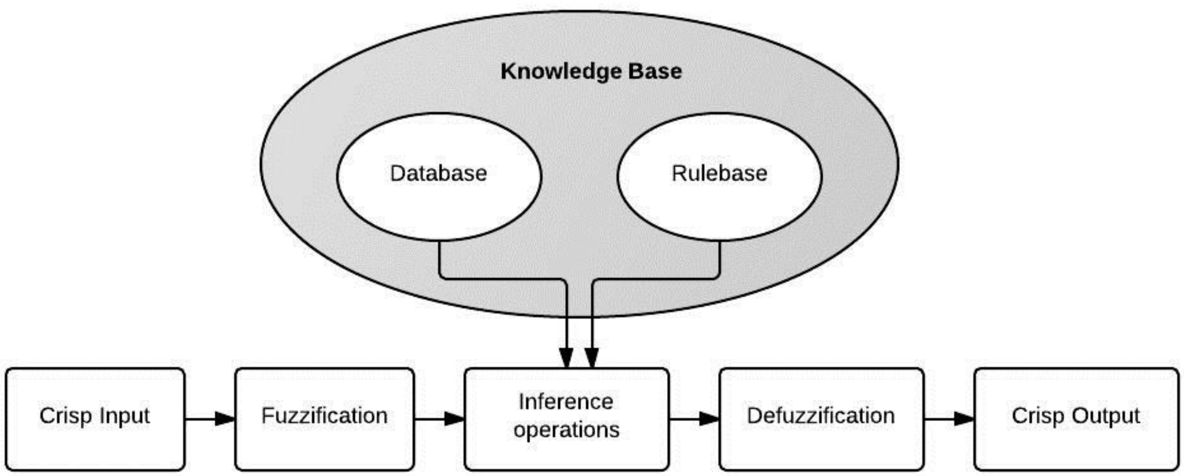


Figure 15: A framework of fuzzy system

(Source: Sivanandam et al., 2007)

Fuzzy inference systems (FIS) are also named as fuzzy rule-based systems, fuzzy model, fuzzy expert system, and fuzzy associative memory which perform the inference operations through a set of fuzzy rules. By formulating suitable IF-THEN rules, the decision making which is a crucial part for the entire system occurs in this unit. There are two categories of fuzzy inference systems called Mamdani and Takagi-Sugeno-Kang (TSK) models. These models have been generally used for solving problems in several applications including decision analysis, expert systems, prediction, data classification, image processing, optimization, control and system identification. The aggregation of rules and defuzzification approach are not same for each type of models.

3.1.2.2.1 Mamdani Fuzzy Model

The Mamdani fuzzy model was proposed by Mamdani and Assilian (1975) which is one of the first developed fuzzy set theory based control systems. The output membership functions of Mamdani model are fuzzy sets. After the aggregation process, defuzzification is necessary for each output variable to convert a fuzzy set to a crisp value.

A defuzzifier which transforms the fuzzy results obtained from inference operations into a crisp output. There are several defuzzification methods such as centroid of area (COA), center of gravity, mean of the maximums, smallest of the maximums. The most common defuzzization method is the COA (Equation 6).

$$y_{COA} = \frac{\int_Y \mu_A(y) y dy}{\int_Y \mu_A(y) dy} \tag{6}$$

Where y_{COA} is the crisp value for the z output and $\mu_A(y)$ is the summation of output membership function (Jang, Sun, & Mizutani, 1997).

Mamdani fuzzy model is the most popular fuzzy methodology which has been applied widely for several problems. Some of the advantages of Mamdani model are its suitability and intuitive for expert opinion, and widely accepted.

3.1.2.2.2 Takagi-Sugeno-Kang (TSK) Fuzzy Model

The Takagi-Sugeno-Kang (TSK) fuzzy model was introduced by Takagi, Sugeno, and Kang (1985) in order to establish a systematic approach to construct fuzzy rules from a given input-output dataset (Jang et al., 1997).

There are similarities to the Mamdani method in several ways. For instance, the first two sections of the fuzzy inference systems (input fuzzification and applying the fuzzy operator) are completely same. The main difference is in the last part. The output membership functions can be linear or constant for TSK model. A common rule in a Sugeno fuzzy model can be defined as following:

If x is A and y is B then z = px + qy + r

where A and B are fuzzy sets and z is a non-fuzzy function.

For a zero-order Sugeno model, the output level z is a constant (p=q =0).

3.1.2.3 Data Clustering

Data clustering allows separating dataset into groups such that identical dataset belong to the same cluster and non-identical dataset to different clusters. The main aim of data clustering is to determine representative behavior of complex system from large dataset. MATLAB functions allow determining number of clusters using input-output dataset. Using clustering algorithms help to generate less complicated fuzzy inference system by using less number of rules. In this research, we applied fuzzy c-means and subtractive clustering algorithms.

3.1.2.3.1 Fuzzy C-Means Clustering

Fuzzy clustering algorithm can be defined as a type of cluster analysis in which the portion of data points to clusters is "fuzzy" in the same sense as fuzzy sets. Fuzzy clustering can be considered as one of the soft computing techniques. In real world problems there is usually imprecise boundary between clusters so that fuzzy clustering can be applied for this kind of dataset.

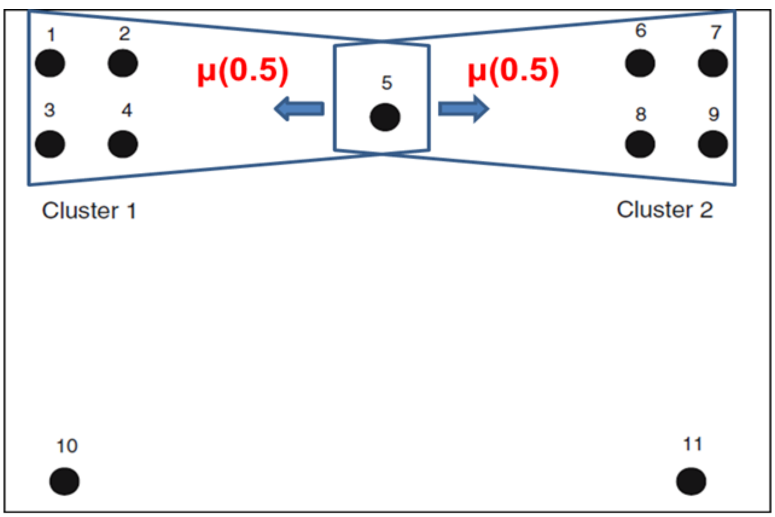


Figure 16: Fuzzy clustering example

Similar to FIS, membership functions are used in fuzzy clustering to represent imprecise terms. For instance, a point can belong to cluster 1 and cluster 2 with same degrees of memberships (μ = 0.5) (Figure 16). The most prominent fuzzy clustering algorithm is the fuzzy c-means (FCM) proposed by Dunn(1973) and improved by Bezdek (1981), a fuzzification of k-Means. The algorithm can be summarized as following sequence of steps:

Step 1: Initialize U=[U_{ij}] matrix, $U^{(0)}$

Step 2: At k-step: calculate the centers vectors $C^{(k)}$ = [C_j] with $U^{(k)}$

$$C = \frac{\sum_{j=1}^{n} u_{ij}^{m} x_j}{\sum_{j=1}^{n} u_{ij}^{m}} \tag{7}$$

Step 3: Update $U^{(k)}$, $U^{(k+1)}$

Step 4: Calculate Euclidean distance

$$d_{ij} = \sqrt{\sum_{i=1}^{n} (x_i - c_i)} \tag{8}$$

Update fuzzy membership matrix U

$$u_{ij} = \frac{1}{\sum_{k=1}^{c} \left(\frac{d_{ij}}{d_{kj}}\right)^{2/(m-1)}} \tag{9}$$

Step 5: if $\|U(k+1) - U(k)\| < \varepsilon$ then STOP; otherwise go to Step 2.

Where m is any real number larger than 1,

u_{ij} : degree of membership of x_i in the cluster j,

x_i : the ith of d-dimensional measured data,

C_j : the d-dimension center of the cluster

3.1.2.3.2 Subtractive Clustering

Subtractive clustering was introduced by Chiu (1994). It is a rapid and one-pass algorithm to determine the amount of clusters and their centers in a given dataset. The subtractive clustering algorithm can be summarized as follows (Equation 10):

$$D_i = \sum_{j=1}^{n} exp\left(-\frac{\|X_i - X_j\|^2}{\left({r_a}/{2}\right)^2}\right) \tag{10}$$

Where D_i is a density measure at data point X_i ,

r_a is a positive constant which represents neighborhood radius. A data point has high density value if its neighboring data points are too much. X_{c_1} is selected as a point that has the largest density D_{c_1}. Then the density measure for each data point X_i is updated as following (Equation 11):

$$D_i = D_i - D_{c_1} exp\left(-\frac{\|X_i - X_{c_1}\|^2}{\left({r_b}/{2}\right)^2}\right) \tag{11}$$

Where r_b is a positive constant. Thus, the data points close to the initial cluster center X_{c_1} will have significantly reduced density measure. These data points will have low probability to be selected again. After the density function is updated, the next cluster center is chosen as a point which has the highest density value. This process continues up to an adequate number of cluster centers are generated.

In summary, the application of FIS in this research was conducted according to the sequence of steps as shown in Figure 17.

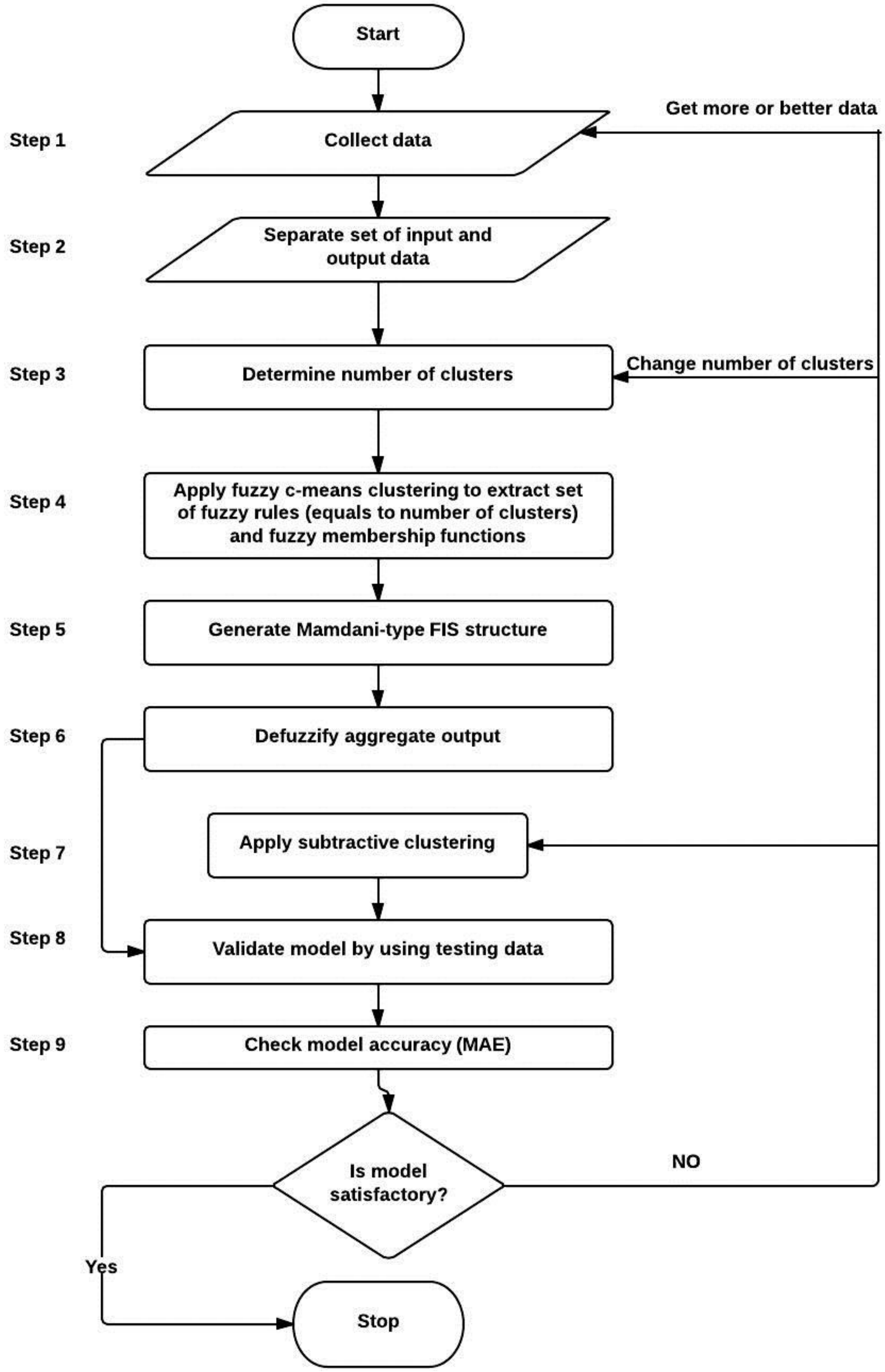


Figure 17: FIS flow diagram used in this study

3.1.3 Adaptive Neuro-Fuzzy Inference Systems (ANFIS)

Neural networks and fuzzy systems have been discussed separately so far. Neuro-fuzzy systems, which are integration of ANNs and FIS, are convincing approaches in order to have both the power of learning and interpretability in a single system (Zaheeruddun and Garima, 2006).The combination includes the characteristics and advantages of both methods (Table 4).

Table 4: Main properties of neural network and fuzzy systems

Neural Network	**Fuzzy System**
Rule-based knowledge cannot be used	Rule-based knowledge can be used
Different learning algorithms available	Cannot learn
COMPLEMENTARY	

(Adapted from Nauck et al., 1997)

The main aim of neuro-fuzzy system is to determine the parameters of a fuzzy system by means of learning methods obtained from neural networks, and their different ways to combine ANNs and Fuzzy Inference Systems (FISs) based on the problem type (Nauck et al., 1997). For example, Jang's Adaptive Neuro-Fuzzy Inference Systems (ANFIS) model which can serve as a basis for generating a set of fuzzy if-then rules with suitable membership functions to achieve the stipulated input-output combinations (Jang, 1993).

Since ANFIS has characteristics of both neural network and fuzzy logic, it is able to handle complex, ill-defined, and nonlinear problems. The architecture of ANFIS includes five layers and the number of neurons in each layer is same with the number of rules.

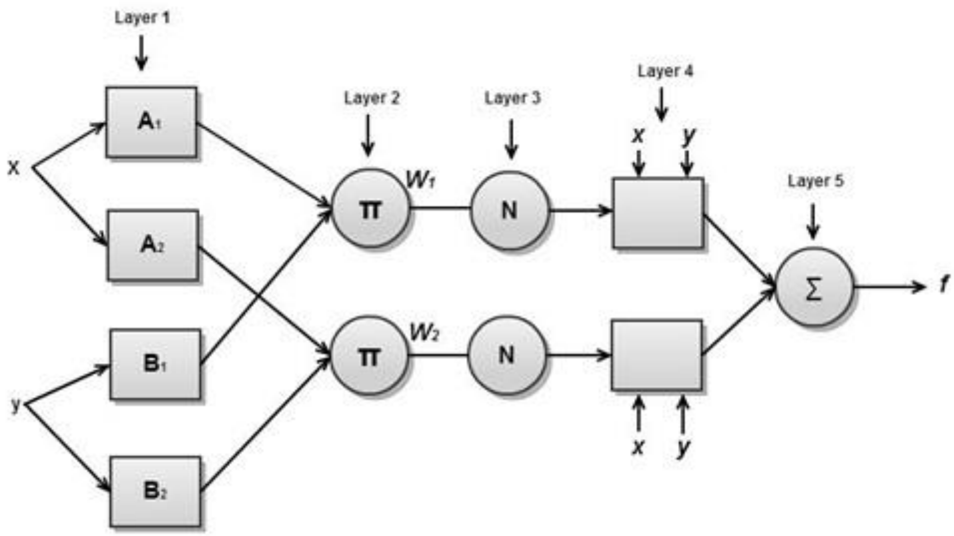


Figure 18: ANFIS architecture

(Adapted from Jang et al., 1997)

ANFIS structure is illustrated in Figure 18. As an illustration, fuzzy inference system with two inputs and one output is considered for simplicity. According to the first-order Sugeno fuzzy model, rule sets can be defined as follows:

Rule 1: If "x" is "A_1" and "y" is "B_1" then $z_1 = p_1$x + q_1 y + r_1

Rule 2: If "x" is "A_2" and "y" is "B_2" then $z_2 = p_2$x + q_2 y + r_2

Where x and y are non-fuzzy inputs, A_i and B_i are fuzzy sets, z_i is the output value; p_i, q_i and r_i are the consequent parameters that are defined in the training process. As illustrated in Figure 18, ANFIS structure has five layers and each layer is described as follows (Jang, 1993):

Layer 1: This layer is the fuzzification layer which contains membership functions. $O_{1,i}$ represents the output of node *i* in layer *l* (Equation 12). Every node *i* in layer 1 is an adaptive unit with a function given by:

$$O_{1,i} = \mu_{A_i}(x), \qquad \text{for } i = 1, 2, \text{ or} \tag{12}$$

$$O_{1,i} = \mu_{B_{i-2}}(y), \qquad \text{for } i = 3, 4,$$

where x and y are input values to node i and A_i and B_{i-2} are linguistic variables (such as old, young) associated with this node. The membership functions of A and B can be any fuzzy membership function.

Layer 2: All nodes in this layer are labeled Π which indicates the multiplication of incoming inputs (Equation 13):

$$O_{2,i} = w_i = \mu_{A_i}(x) \text{ x } \mu_{B_i}(y), \;\; i = 1, 2. \tag{13}$$

Each node output is called firing strengths (weights) of the rules.

Layer 3: All nodes in this layer are labeled N. The ratio of the ith rule's firing strength to the sum of all rules' firing strengths is calculated in this layer (Equation 14):

$$O_{3,i} = \overline{w}_i = \frac{\mathrm{w_i}}{\mathrm{w_1+w_2}}, \mathrm{i} = 1, 2 \tag{14}$$

Layer 4: Each node in this layer includes linear functions (Equation 15):

$$O_{4,i} = \overline{w}_i f_i = \overline{w}_i(p_i\mathrm{x} + q_i \mathrm{\ y} + r_i) \tag{15}$$

where $\overline{w}_i$ *is an output from layer 3 and* $\{ p_i, q_i, r_i\}$ are the consequent parameters set.

Layer 5: In this layer, there is a single node labeled ∑ which aggregates the total output using the sum of all incoming signals (Equation 16):

$$O_{5,i} = overall\ output = \sum_i \overline{w}_i f_i = \frac{\sum_i w_i f_i}{\sum_i w_i} \tag{16}$$

3.1.3.1 ANFIS Input Selection

An input selection approach for neuro-fuzzy approaches using ANFIS was proposed by Jang (1996). In his paper, this approach was tested using two applications: “the nonlinear regression problem of automobile gas mileage prediction, and nonlinear system identification using Box and Jenkins gas furnace data” (Jang, 1996). When using high number of inputs for generating of ANFIS structure, the number of rules and membership functions increase at the same time. Too many parameters may have some problems as follows:

- complexity,
- diminishing its applicability,
- too much computation time,

In real world applications, problems usually have tens of inputs candidate during the model generation. Among these inputs, it is required to determine the priorities and select the most efficient inputs that mostly affect output values.

Since we have 89 inputs in our research problem, to handle these possible problems and reduce complexity, we applied ANFIS input selection method in this research. In summary, the application of ANFIS in this research was conducted according to the sequence of steps as shown in Figure 19.

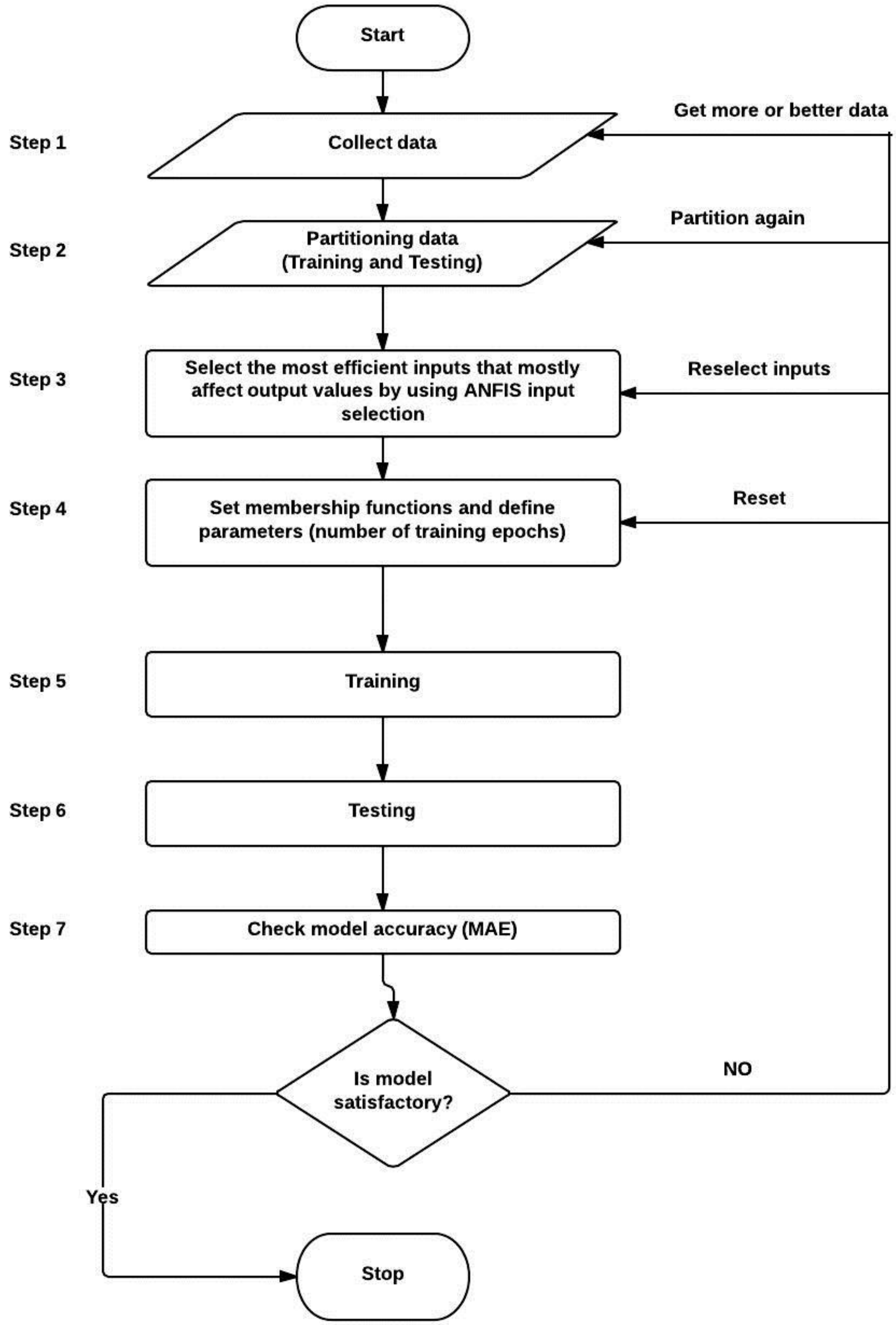


Figure 19: ANFIS flow diagram used in this study

3.2 The dataset

Two different kinds of Afghanistan datasets were provided by HSCB program management (data collected between 2002 and 2010), and utilized in this research. 1) The adverse event dataset which includes information regarding the date of event, incident type, number of people killed, wounded and hijacked, province, city, district, description of the event, and simple event summary. 2) The infrastructure development dataset includes information regarding the urban and rural population density, province, city, district, country, project types, allocated budget information for different sectors, number of aids in each sector, types of construction, and usage of air fields. These datasets were provided in seperate files at the beginning. For analysis purposes, they were combined using time and district information that are common characteristics in both datasets. The dataset used in this study is monthly based and at district level (Figure 20). The dataset was sorted based on the the order of year, month, and province info. The partial snapshots of dataset represented in Appendix A.

In this research, the total budget of fourteen project types considered at years t=0 (i.e. current year), t-1 (previous year), and t-2 (two years ago); the total number of fourteen economic aid projects at years t=0 (i.e. current year), t-1 (previous year), and t-2 (two years ago); number of adverse events in previous month; urban and rural population density for male and female are used for the estimation purpose of 4 outputs reflecting total numbers of adverse events, number of people killed, wounded, and hijacked in year t+1. Thus, we were able to include a total of 89 inputs and 4 outputs reflecting adverse events. The format of the data used in this research is represented in Table 5.

Data_Year	Data_Month	PROV_34_ID	DIST_34_ID	Region
2004	12	33	3305	Western
2004	12	33	3306	Western
2004	12	33	3307	Western
2004	12	33	3308	Western
2004	12	33	3309	Western
2004	12	33	3310	Western
2004	12	33	3311	Western
2004	12	34	3401	South Western
2004	12	34	3402	South Western
2004	12	34	3403	South Western
2004	12	34	3404	South Western
2004	12	34	3405	South Western
2004	12	34	3406	South Western
2005	1	1	101	Central
2005	1	1	102	Central
2005	1	1	103	Central
2005	1	1	104	Central
2005	1	1	105	Central
2005	1	1	106	Central
2005	1	1	107	Central
2005	1	1	108	Central
2005	1	1	109	Central
2005	1	1	110	Central
2005	1	1	111	Central

Figure 20: Year, month, province, district, and region info of partial training dataset

All data used for this research reflect incidents or projects that took place between 2004 and 2010. The data was grouped for training and testing as follows: years between 2004 and 2009 (totally 28800 records for training purpose) and year 2010 (totally 4800 records for testing). Table 6 and 7 represent the empirical dataset used for model development.

Table 5: The variables used in model construction

Input variable		Output variable	
$P_{t,t-1,t-2}$	Agriculture	y_t	Number of Adverse Events (Dead, Wounded, Hijacked, and Total number of adverse events)
$P_{t,t-1,t-2}$	Capacity building		
$P_{t,t-1,t-2}$	Commerce and industry		
$P_{t,t-1,t-2}$	Community development		
$P_{t,t-1,t-2}$	Education		
$P_{t,t-1,t-2}$	Emergency assistance		
$P_{t,t-1,t-2}$	Energy		
$P_{t,t-1,t-2}$	Environment		
$P_{t,t-1,t-2}$	Gender		
$P_{t,t-1,t-2}$	Governance		
$P_{t,t-1,t-2}$	Health		
$P_{t,t-1,t-2}$	Security		
$P_{t,t-1,t-2}$	Transport		
$P_{t,t-1,t-2}$	Water and sanitation		
$A_{t,t-1,t-2}$	Agriculture		
$A_{t,t-1,t-2}$	Capacity building		
$A_{t,t-1,t-2}$	Commerce and industry		
$A_{t,t-1,t-2}$	Community development		
$A_{t,t-1,t-2}$	Education		
$A_{t,t-1,t-2}$	Emergency assistance		
$A_{t,t-1,t-2}$	Energy		
$A_{t,t-1,t-2}$	Environment		
$A_{t,t-1,t-2}$	Gender		
$A_{t,t-1,t-2}$	Governance		
$A_{t,t-1,t-2}$	Health		
$A_{t,t-1,t-2}$	Security		
$A_{t,t-1,t-2}$	Transport		
$A_{t,t-1,t-2}$	Water and sanitation		
Y_{t-1}	Adverse event number at month t-1		
U_f	Urban female population density		
U_m	Urban male population density		
R_f	Rural female population density		
R_m	Rural male population density		

*$P_{t,t-1,t-2}$: Project budget amount at year t, t-1, and t-2 ($)
*$A_{t,t-1,t-2}$: Number of projects at year t, t-1, and t-2
t: years between 2004 and 2010
t-1: years between 2003 and 2009
t-2: years between 2002 and 2008

Ninety six different prediction models were developed based on number of output variables, methodology type, the number of regions and summarized for Afghanistan (Figure 21). Each region has different numbers of provinces and districts, and training and testing information for each region is collected in seperate files to be ready for the regional analysis (Table 8).

Table 6: Empirical training dataset for years between 2004 and 2009

Project budget			**Number of projects**			**Total number of adverse events: historical data**	**Population density**	**Output: Total number of adverse events**
year t-2	year t-1	year t	year t-2	year t-1	year t	month t-1		year t
Jan 2002 . . Dec 2007	Jan 2003 . . Dec 2008	Jan 2004 . . Dec 2009	Jan 2002 . . Dec 2007	Jan 2003 . . Dec 2008	Jan 2004 . . Dec 2009	Dec 2003 . . Nov 2009	year 2008	Jan 2004 . . Dec 2009

Table 7: Empirical testing dataset for 2010

Project budget			**Number of projects**			**Total number of adverse events: historical data**	**Population density**	**Output: Total number of adverse events**
year t-2	year t-1	year t	year t-2	year t-1	year t	month t-1		year t
Jan 2008 . . Dec 2008	Jan 2009 . . Dec 2009	Jan 2010 . . Dec 2010	Jan 2008 . . Dec 2008	Jan 2009 . . Dec 2009	Jan 2010 . . Dec 2010	Dec 2009 . . Nov 2010	year 2008	Jan 2010 . . Dec 2010

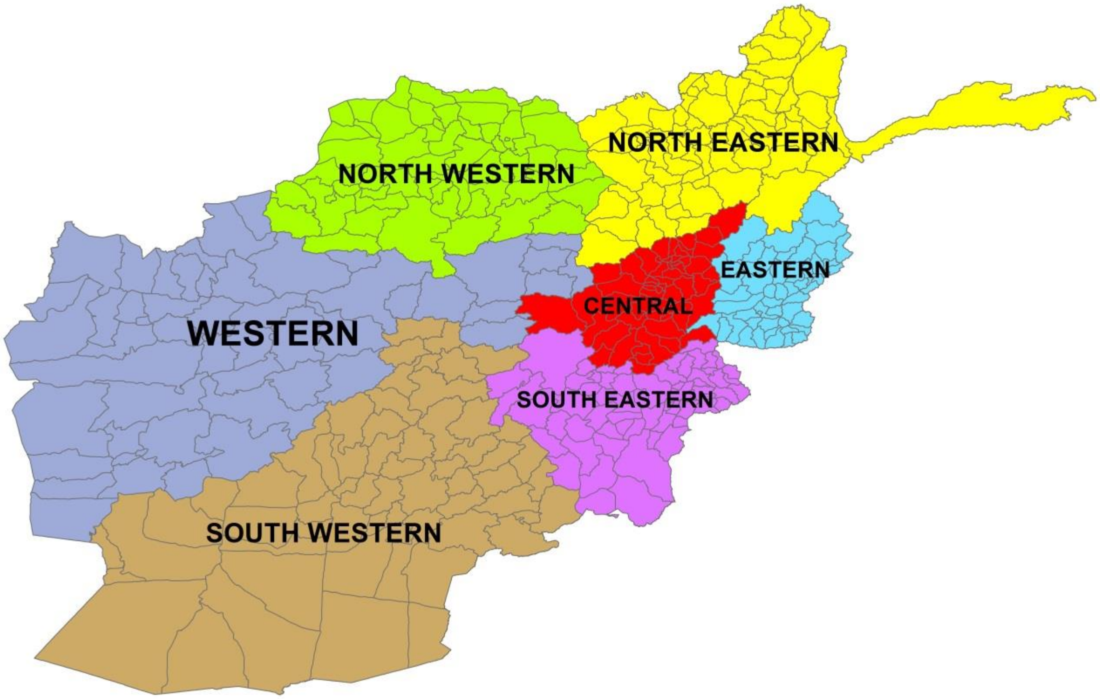


Figure 21: Regions of Afghanistan

Table 8: Province and district info for each region

Region	Number of Province	Number of District	Number of records for training	Number of records for testing	Total number of records
Central	6	55	3960	660	4620
Eastern	4	50	3600	600	4200
North Eastern	4	67	4824	804	5628
South Eastern	4	62	4464	744	5208
Western	5	51	3672	612	4284
North Western	5	55	3960	660	4620
South Western	6	60	4320	720	5040
Afghanistan (Total)	34	400	28800	4800	33600

3.3 Performance Metrics

Performance metrics have been used for calculating the error (difference between actual and predicted values) in the model. There are several performance metrics including Mean Square Error (MSE), Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and MAPE Mean Absolute Percentage Error (MAPE). The RMSE and the MAE are dimensioned measures of average model prediction error. Willmott and Matsuura(2005) stated that RMSE is not appropriate as an indicator of average error. In other words, interpretation of RMSE is unclear because there is no persistent functional relationship between RMSE and average error. They concluded that MAE must be used as the most natural measure of average error.

In this research, and in order to calculate the performance of ANN, ANFIS, and FIS models, model accuracy was evaluated based on the MAE between the predicted and actual values. The following equations 17 and 18 are used for this calculation:

$$e_i = (P_i - A_i) \qquad i = 1,2,3, \ldots \ldots, n \tag{17}$$

$$MAE = \frac{1}{N} \sum_{i=1}^{N} |e_i| \tag{18}$$

Moreover, prediction accuracy was also tested within ±1 range (difference between actual and predicted value). The following equation 19 is used for the calculation of this percentage value:

Percentage value =

((total number of e_i value that satisfies $|e_i| \leq 1$) / N)*100. (19)

Where P_i and A_i are predicted and actual values, respectively,

e_i: prediction error for each record,

N: total number of testing records.

CHAPTER IV: RESULTS

This chapter presents the model development and results of ANN, FIS, and ANFIS model. The performance comparison of model is included at the end of the chapter. Finally, sensitivity analysis was performed based on the best prediction model to assess the potential impact of regional infrastructure development efforts on occurrence of adverse events.

To meet the research objectives, three prediction models were applied as described in previous section. The results were classified according to the prediction approach and dependent variables: Artificial Neural Networks (ANNs), Fuzzy Inference System (FIS), and Adaptive Neuro Fuzzy Inference System (ANFIS); under each methodology, prediction of the number of people killed, wounded, and hijacked, and total number of adverse events were presented in this order.

The data was grouped for training and testing as follows: years between 2004 and 2009 (for training purpose), and year 2010 (for testing). For each model, the training and testing percentages are 85.71% and 14.29% respectively (Table 9).

Table 9: Percentage values of training and testing records for each region

Region	**Percentage for training (2004-2009)**	**Percentage for testing (2010)**	**Total number of records (2004-2010)**
Central	3960 (85.71%)	660 (14.29%)	4620 (100%)
Eastern	3600 (85.71%)	600 (14.29%)	4200 (100%)
North Eastern	4824 (85.71%)	804 (14.29%)	5628 (100%)
South Eastern	4464 (85.71%)	744 (14.29%)	5208 (100%)
Western	3672 (85.71%)	612 (14.29%)	4284 (100%)
North Western	3960 (85.71%)	660 (14.29%)	4620 (100%)
South Western	4320 (85.71%)	720 (14.29%)	5040 (100%)
Afghanistan (Total)	28800 (85.71%)	4800 (14.29%)	33600 (100%)

For model development, eighty-nine input parameters and four desired output values have been used. Fourteen developmental and economic improvement project types were selected based on allocated budgets values and number of projects at different time periods, population density, and previous month adverse event numbers selected as independent variables. A total of 4 outputs reflecting the adverse events in terms of the number of people killed, wounded, hijacked, and total number of adverse events have been estimated using soft computing techniques.

Before applying prediction models, correlation analysis was conducted using training data (between 2004 and 2009) to see the statistically significant relationships between independent and dependent variables. Correlation analysis is used to describe the negative or positive relationship between two variables. For each independent variable, the p-value was tabulated. Based on the correlation analysis results, we can conclude that most independent variables are significantly related to the dependent variables ($p<0.05$) (Appendix B).

For number of people killed, 26 out of 28 project budgets and number of projects in year (t-2), 21 out of 28 project budgets and number of projects in year (t-1), 18 out of 28 project budgets and number of projects in year (t), urban and rural population density, and number of people killed in previous month (t-1) were found to be significantly related.

For number of people wounded, 25 out of 28 project budgets and number of projects in year (t-2), 21 out of 28 project budgets and number of projects in year (t-1), 19 out of 28 project budgets and number of projects in year (t), urban population density, and number of people wounded in previous month (t-1) were found to be significantly related.

For number of people hijacked, 13 out of 28 project budgets and number of projects in year (t-2), 9 out of 28 project budgets and number of projects in year (t-1), 6 out of 28 project budgets and number of projects in year (t), rural population density, and number of people hijacked in previous month (t-1) were found to be significantly related. The reason for being less correlated with number of people hijacked can be more zero values observed in number of people hijacked than other dependent variables.

For total number of adverse events, 27 out of 28 project budgets and number of projects in year (t-2), 22 out of 28 project budgets and number of projects in year (t-1), 19 out of 28 project budgets and number of projects in year (t), urban and rural population density, and total number of adverse events in previous month (t-1) were found to be significantly related. The results demonstrate that past projects are more related with dependent variables.

The whole country was divided into seven regions for analysis purposes. The reason for dividing the country into seven regions was to analyze the group of districts which are neighborhoods or close to each other. Dividing the country allows us to analyze similar patterns together, and assess the potential impact of regional development efforts on occurrence of adverse events. Regional analysis increased the performance of models. It was observed that the prediction performance of some regions had better than the entire country.

Totally ninety-six different models were developed and investigated for Afghanistan and seven divided regions. These models have been developed by three methodologies which the mathematical details were explained in previous section. To compare three prediction models on the same basis, all of these models were developed under the MATLAB R2011b Version 7.13.0 and the corresponding MATLAB codes are represented in Appendix C.

4.1 ANN Model Development

Different types of ANNs have been applied successfully since 1980s. For the models development, we focused on the feed-forward neural network models among several network architectures presented in the previous section. As a network training algorithm, the Levenberg-Marquardt algorithm was applied for all ANN models. As a transfer (activation) function, we selected log-sigmoid function for hidden nodes and hyperbolic tangent function for output nodes. For all dependent variables, the feed-forward neural network models were considered with different number of neurons up to fifty in a hidden layer that meet the minimum mean absolute error (MAE) objective.

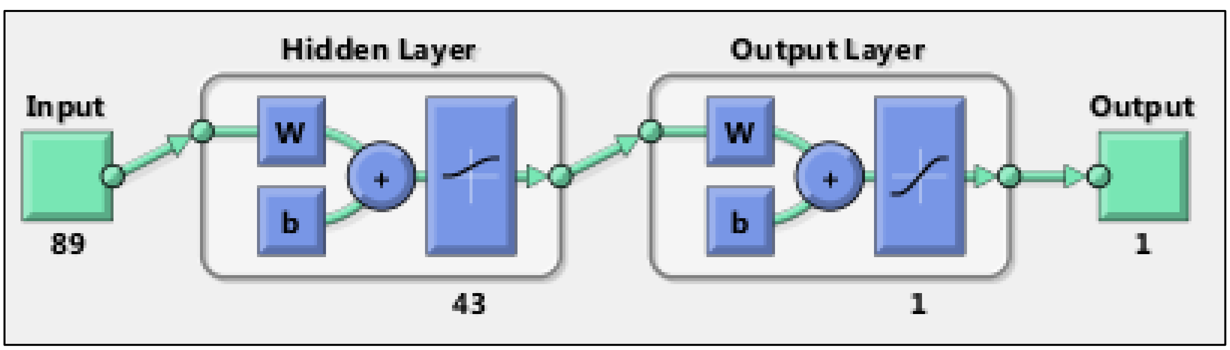


Figure 22: Illustration of ANN model with forty-three neurons in a hidden layer for eighty-nine input parameters

The summary of parameters defined in this research is as follows:

- Number of hidden layer = 1
- Number of neurons in a hidden layer = varies from 1 to 50

- Number of output layer units = 1
- Momentum coefficient = 0.6
- Learning rate = 0.3
- Maximum number of epochs to train = 1000
- Error goal to stop training = 0

Based on number of neurons in a hidden layer (Figure 22), there are fifty combinations of the ANN structures tested to base testing performance of ANNs in predicting number of adverse events and the best configuration for each dependent variable was represented in the following sections.

4.1.1 Prediction of number of people killed

ANN experimental results of configurations for number of people killed and each region based on number of neurons in a hidden layer were represented in Table 10. Based on Table 10, the minimum MAE values were highlighted and Table 11 provides information about the best ANN model configuration for number of people killed in each region.

Based on the information in Table 11, the MAE values vary between 0 and 1 except for south western region. Corresponding percentage values of prediction performance vary around 90%. Central, eastern, north eastern and north western regions had better prediction performance percentage value than Afghanistan. North western region had the best prediction performance accuracy among seven regions, the MAE value was found as 0.21 and the percentage value of prediction performance was found as 95.75%. On the other side, south western region had the worst prediction performance accuracy, the MAE value was calculated as 1.729 and the percentage value of prediction performance was found as 77.5%

Figure 23 provides information about ANN predicted and observed values of number of people killed for Afghanistan and the regions of central, eastern, and north eastern and Figure 24 provides same information type for the regions of north western, south eastern, south western and western.

Table 10: Number of people killed – ANN best configuration highlighted for each region based on number of neurons in a hidden layer

	Mean Absolute Error (MAE)							
	Afgh.	**Central**	**Eastern**	**N.East.**	**S.East.**	**Western**	**N.Western**	**S.West.**
1	0.6671	0.4091	0.4273	0.3812	0.8777	0.5395	0.4928	2.0559
2	0.6668	0.5218	0.2856	0.4100	0.8105	0.5376	1.9176	1.9167
3	0.7256	0.4839	0.5220	0.4337	1.0548	0.9453	0.2167	1.9131
4	0.6671	0.4091	0.2830	0.3818	0.8077	0.6179	0.2349	2.0797
5	0.6666	0.9452	0.3275	0.4612	0.9395	0.8089	0.5157	2.0234
6	0.8512	0.4840	1.0796	0.7143	0.8665	1.0901	0.2562	1.8882
7	0.6671	0.4091	0.3693	11.7430	0.8105	0.5376	0.2167	1.9115
8	0.6671	0.5759	0.2833	7.7209	0.8076	0.5376	0.2179	1.9167
9	0.6717	0.5578	1.0861	0.6688	0.8453	0.7099	0.2177	2.6513
10	1.4571	0.7312	0.6492	0.4707	1.0496	1.3309	4.3613	1.9893
11	1.0326	0.7892	0.9684	5.9917	1.6117	0.9221	7.8459	1.8624
12	0.8311	0.4552	1.9344	0.4890	1.3407	0.6741	4.2126	1.8625
13	0.9798	1.2636	0.3209	6.9697	0.8177	3.8100	0.2167	1.9625
14	0.6788	0.5710	0.5848	1.6395	0.8006	1.4416	0.3207	2.6186
15	5.3157	1.4738	1.6202	1.2072	0.8330	2.3361	0.2795	1.9575
16	1.0996	1.1031	0.4872	10.9002	0.8489	0.6218	0.4748	1.8885
17	0.6929	0.4327	0.4271	3.7134	0.8748	0.5999	0.4916	2.0008
18	2.5220	0.4680	0.5646	9.3438	0.9963	0.5357	0.6850	1.9072
19	0.6921	0.7361	0.3513	0.9301	0.8526	0.5613	4.0582	1.9426
20	0.6707	0.4907	0.3472	1.0363	0.8025	0.8626	0.3341	1.9201
21	1.0223	0.8091	1.0093	0.6402	0.8349	1.1369	0.8863	1.9189
22	0.9876	0.4958	1.4989	0.7584	1.2189	0.6250	0.2252	1.9078
23	1.2179	0.4099	0.5751	0.3827	1.0281	3.6837	1.5381	1.9305
24	0.6789	0.8351	0.2929	0.3819	0.8045	0.5474	0.4431	1.9132

	Mean Absolute Error (MAE)							
	Afgh.	**Central**	**Eastern**	**N.East.**	**S.East.**	**Western**	**N.Western**	**S.West.**
25	0.6908	0.4206	0.2859	0.4041	0.8711	0.5439	2.3661	3.6385
26	0.6838	1.1490	0.7959	0.5370	1.0994	1.7890	0.9124	1.9132
27	0.7483	1.0871	0.3020	1.7085	0.8633	0.5388	0.4051	1.9153
28	0.7312	0.5049	0.5423	9.6483	0.8724	0.5381	0.9728	2.0134
29	0.8233	0.4091	1.1950	0.3818	0.8858	0.5376	0.2167	1.9167
30	2.9636	0.4465	0.2833	0.3816	0.9513	0.7421	0.2168	1.9167
31	0.7231	0.8669	1.0473	1.9111	0.8420	0.7922	0.2307	1.9856
32	0.6671	0.4901	1.1589	0.6962	2.6423	0.5376	0.2240	1.9170
33	0.6671	0.4100	0.2961	10.5519	0.8105	0.5376	0.3686	1.9510
34	0.6781	0.5942	1.6046	0.6415	0.9557	1.3959	1.4619	1.9289
35	0.6692	0.5529	0.3072	0.9232	0.8539	1.4913	1.2173	3.2203
36	0.6671	0.4102	0.2882	0.4575	1.1441	1.0505	1.0372	1.9898
37	0.8048	1.0700	0.2935	2.1104	4.9415	3.2333	0.4583	2.0199
38	1.0544	0.5166	0.2870	0.3819	0.8539	0.6686	0.2326	2.1250
39	0.8475	0.4092	0.2834	0.3818	0.8105	0.8848	5.1417	3.0897
40	0.6670	0.9360	0.3611	1.2363	2.0449	0.5666	0.4058	1.7293
41	0.6682	0.4091	4.0916	0.4520	0.8796	0.5942	0.7131	1.9373
42	0.6827	0.4593	0.7035	0.5096	0.9286	0.5451	0.2190	1.9057
43	0.7468	0.5816	0.3529	2.2365	0.8132	0.7428	1.2043	1.8552
44	1.1060	1.8646	0.2833	0.7111	0.8194	3.0403	0.2363	1.9341
45	0.6673	0.4206	1.1952	6.4350	0.9128	0.5447	0.2167	1.8870
46	0.9343	0.8600	0.3763	3.7126	0.8486	1.9084	1.3217	1.9024
47	0.6671	0.5455	0.2833	0.4789	0.8185	0.8447	0.6927	2.0861
48	0.7068	0.5293	0.4904	0.4356	0.8105	3.5104	1.5157	2.1552
49	0.7083	0.6080	1.4638	0.3838	1.5607	0.9221	0.3262	1.8949
50	0.6870	1.2618	0.2903	0.3820	1.0827	0.7399	0.5269	1.9004

Table 11: ANN best model configuration for number of people killed in each region

Region	**MAE**	**Prediction performance**	**Number of neurons in a hidden layer**
Afghanistan	0.6666	90.104%	5
Central	0.4091	93.484%	29
Eastern	0.2829	93.333%	4
North Eastern	0.3812	93.905%	1
Western	0.5357	89.870%	18
South Eastern	0.8006	88.306%	14
South Western	1.7292	77.501%	40
North Western	0.2167	95.757%	29

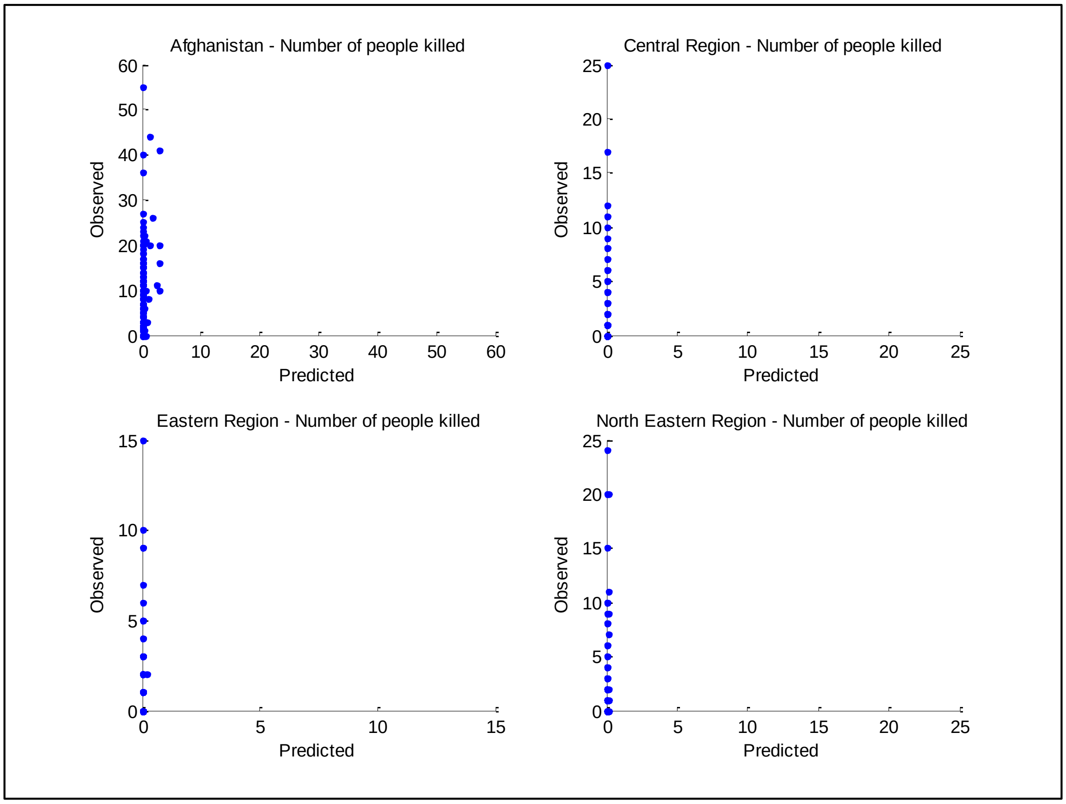


Figure 23: ANN predicted and observed values of number of people killed for Afghanistan, central, eastern, and north eastern regions

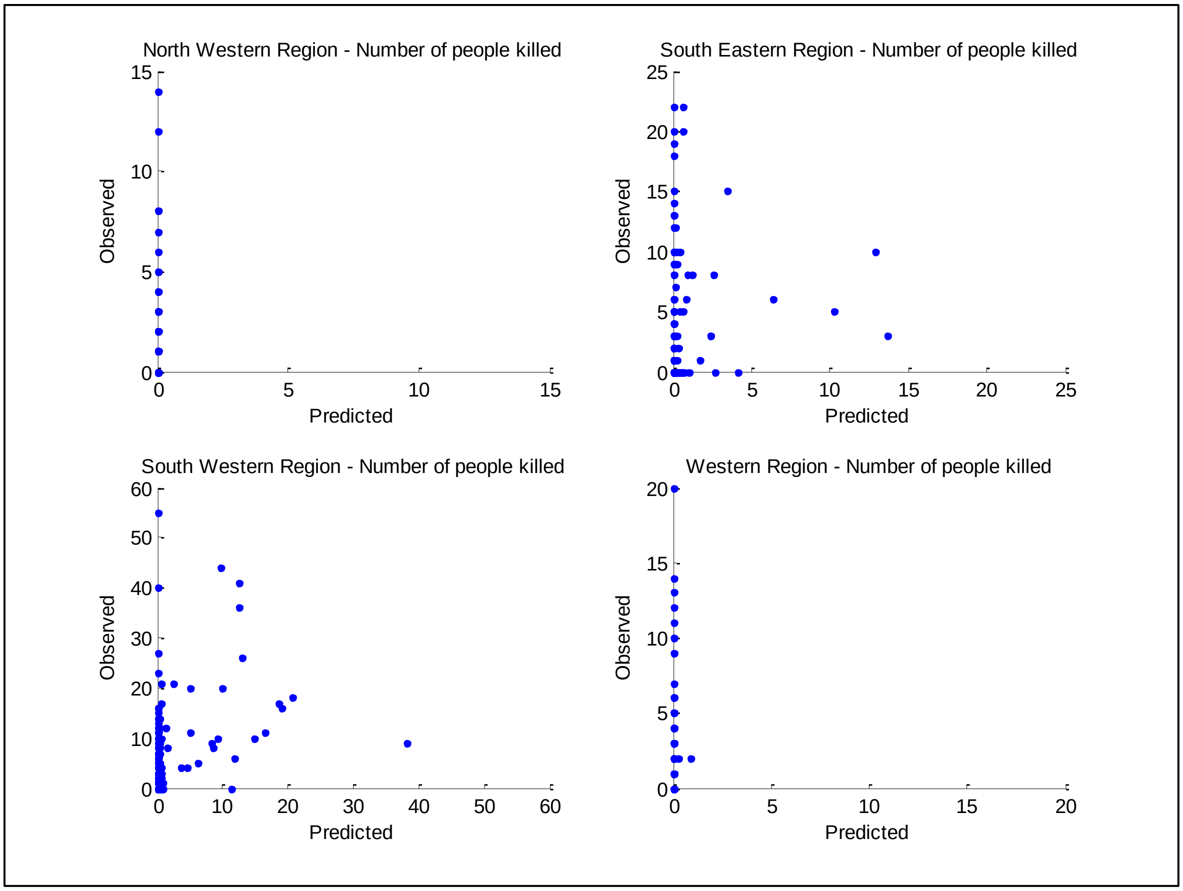


Figure 24: ANN predicted and observed values of number of people killed for north western, south eastern, south western, and western regions

4.1.2 Prediction of number of people wounded

Experimental results of configurations for number of people wounded and each region based on number of neurons in a hidden layer were represented in Table 12. Based on Table 12, the minimum MAE values were highlighted and Table 13 provides information about the best ANN model configuration for number of people wounded in each region. Based on the information in Table 13, the MAE values vary between 0 and 1 except for Afghanistan, south eastern and south western region. Corresponding percentage values of prediction performance vary around 90%. Central, north eastern, western and north western regions had better prediction performance percentage value than Afghanistan. North western region had the best prediction performance accuracy among seven regions, the MAE value was found as 0.3833 and the percentage value of prediction performance was found as 94.54%. On the other side, south western region had the worst prediction performance accuracy, the MAE value was calculated as 2.248 and the percentage value of prediction performance was found as 79.02%

Figure 25 provides information about ANN predicted and observed values of number of people wounded for Afghanistan and the regions of central, eastern, and north eastern and Figure 26 provides same information type for the regions of north western, south eastern, south western and western.

Table 12: Number of people wounded – ANN best configuration highlighted for each region based on number of neurons in a hidden layer

	Mean Absolute Error (MAE)							
	Afgh.	**Central**	**Eastern**	**N.East.**	**S.East.**	**Western**	**N.Western**	**S.West.**
1	1.0099	0.8834	1.3579	0.6138	1.3913	0.6244	6.6273	2.5612
2	1.0094	0.8834	1.0215	0.5980	2.1593	0.5523	5.6679	2.4306
3	1.1558	2.9831	1.0851	0.6787	2.9755	0.5582	0.3833	3.0932
4	1.0098	1.0661	0.9750	0.5958	1.1545	0.5523	1.2160	2.4306
5	1.5902	0.9748	19.1119	2.6727	2.2492	0.5835	1.2020	2.9096
6	1.7614	1.3866	12.1989	1.0511	1.5908	0.5932	2.6188	4.5751
7	1.0103	1.0894	1.0122	25.9523	1.1546	11.0237	0.3833	2.3670
8	1.0098	0.8990	0.9750	15.4650	1.1546	0.5523	0.5095	2.4306
9	28.2875	1.1063	1.3799	0.8272	1.8406	0.6457	0.3904	2.4877
10	1.1981	1.3131	1.2912	0.6678	1.4130	6.1511	28.4030	7.6402
11	1.0579	1.2362	1.0925	0.7156	2.5253	1.1065	22.5480	6.2313
12	1.9764	8.5302	2.9348	0.6590	2.1088	0.8364	11.5871	2.6871
13	1.5017	4.4076	0.9898	1.9188	20.3254	7.8832	0.3833	2.4644
14	6.5671	3.8796	5.5732	2.9756	1.6618	0.5636	2.4915	2.8154
15	1.0212	1.6692	18.1470	13.4421	2.0712	0.6651	0.4975	3.4426
16	1.7308	1.2647	1.4482	2.6462	1.2799	2.7072	0.5167	2.9574
17	1.3399	2.7173	1.1097	1.0461	1.5125	0.6096	17.1188	2.3929
18	1.8389	3.2153	0.9696	3.4989	2.2109	0.6596	1.2836	2.2486
19	1.0650	4.6528	1.1171	1.6186	1.1218	8.2215	10.5146	3.4994
20	1.2733	1.3684	1.1567	0.6338	1.4380	1.4140	0.8138	2.8617

	Mean Absolute Error (MAE)							
	Afgh.	**Central**	**Eastern**	**N.East.**	**S.East.**	**Western**	**N.Western**	**S.West.**
21	1.0428	1.0010	4.3195	0.6083	1.2452	0.9501	0.9266	2.7765
22	4.7171	1.2449	9.8925	4.3733	13.1529	0.5547	0.6022	19.5903
23	3.7567	1.3988	1.1507	0.5957	1.9573	2.3183	0.9876	12.6474
24	1.0069	1.6295	1.0995	0.5997	8.9848	0.8620	5.0861	3.5501
25	1.5271	0.9246	0.9750	0.6102	1.5927	0.7792	1.0379	3.5168
26	1.1640	21.4156	4.1127	14.1486	1.2726	0.9175	1.0950	3.5020
27	34.9512	1.1155	1.0280	16.9281	3.2741	0.5606	0.5847	2.4270
28	1.8649	0.8875	2.3898	2.4706	3.5056	20.7090	1.1817	7.3222
29	1.0096	0.8833	1.0916	7.6338	1.1546	4.2763	0.4513	2.4306
30	1.0098	0.8864	0.9750	0.5959	2.0323	0.5523	0.3850	2.4306
31	1.2107	2.2075	0.9648	0.9742	1.8253	0.5860	0.7469	19.4693
32	1.0098	0.9304	0.9939	0.7863	3.4381	0.5802	11.7036	2.5391
33	1.0098	0.9062	0.9493	20.0428	1.2540	0.7278	11.9803	2.4305
34	1.0098	2.3297	1.5132	0.6499	1.5868	6.4989	2.1521	2.4411
35	1.4987	2.4827	1.3574	0.5958	1.4512	16.1674	10.7439	19.7445
36	1.0097	0.8962	0.9988	0.6003	1.2620	0.5519	3.0579	7.4678
37	2.4936	14.8054	1.2076	0.6262	1.2242	7.2319	4.4278	2.4253
38	2.1755	0.9553	16.0981	0.5958	1.4091	1.9854	2.4069	2.4220
39	92.7751	0.8907	2.5275	0.5958	1.1546	0.5523	22.1214	2.8126
40	1.3064	1.5511	1.0123	1.7735	1.9187	0.7577	3.6269	4.2377
41	1.0175	2.2599	1.2209	0.7763	6.1617	1.3689	0.6205	3.8649
42	1.0660	0.8833	1.2625	1.3113	2.1474	0.5720	0.7164	2.8418
43	1.0270	1.2802	1.4429	2.8111	1.4930	0.5370	0.4168	2.9548
44	1.0377	0.9065	0.9784	1.6884	1.2196	6.0109	2.0210	14.6118
45	4.0533	0.8872	3.4667	11.6435	1.4359	0.6624	0.3833	2.4565
46	1.0427	7.1004	1.1116	0.8158	1.7787	1.0029	1.6759	2.3305
47	1.0098	1.0985	0.9750	0.7948	1.1546	0.6133	12.3270	2.5389
48	1.1704	1.6467	0.9726	0.6441	1.1546	0.6129	1.8060	2.6536
49	1.0489	1.0945	3.6629	0.6139	1.6426	0.5644	0.3847	2.3263
50	1.0939	1.1503	1.4062	18.0831	2.4363	0.7569	0.4250	5.5243

Table 13: ANN best model configuration for number of people wounded in each region

Region	MAE	Prediction performance	Number of neurons in a hidden layer
Afghanistan	1.0069	89.208%	24
Central	0.8834	92.575%	2
Eastern	0.9493	87.332%	33
North Eastern	0.5957	92.911%	23
Western	0.5370	90.033%	43
South Eastern	1.1218	87.365%	19
South Western	2.2486	79.023%	18
North Western	0.3833	94.545%	45

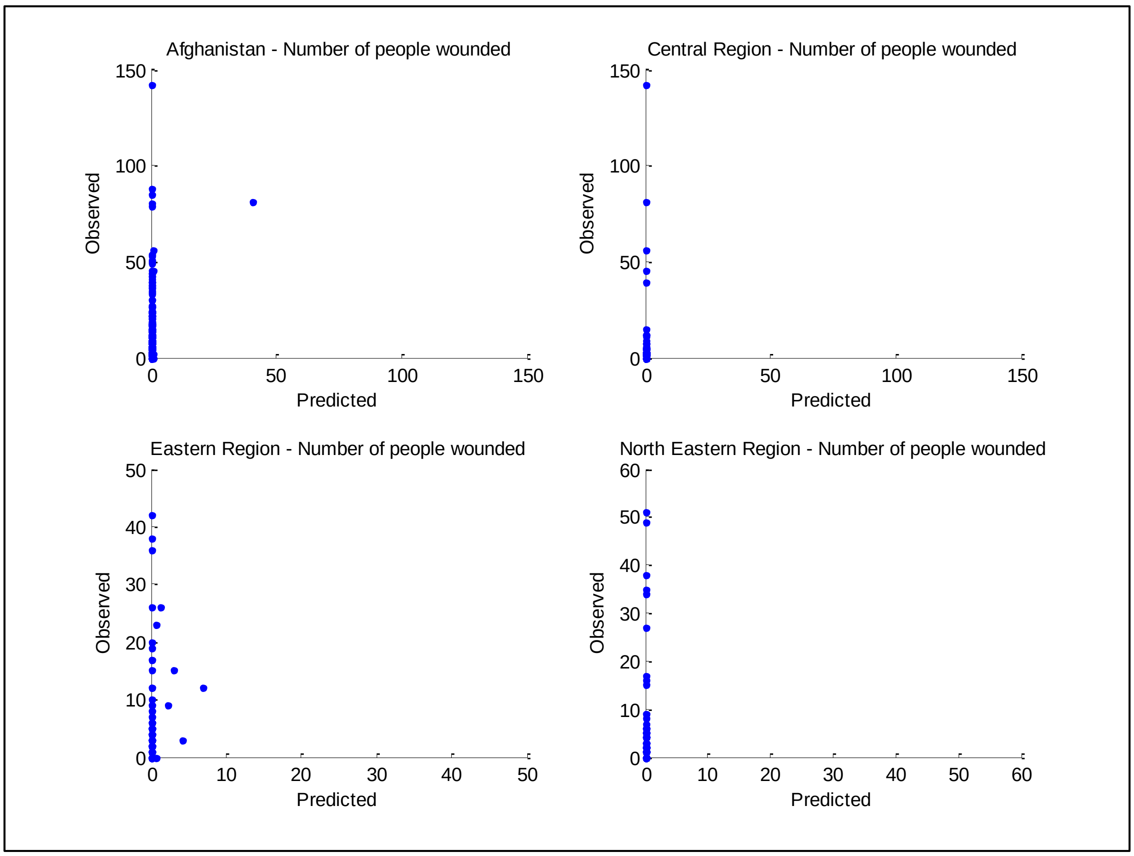


Figure 25: ANN predicted and observed values of number of people wounded for Afghanistan, central, eastern, and north eastern regions

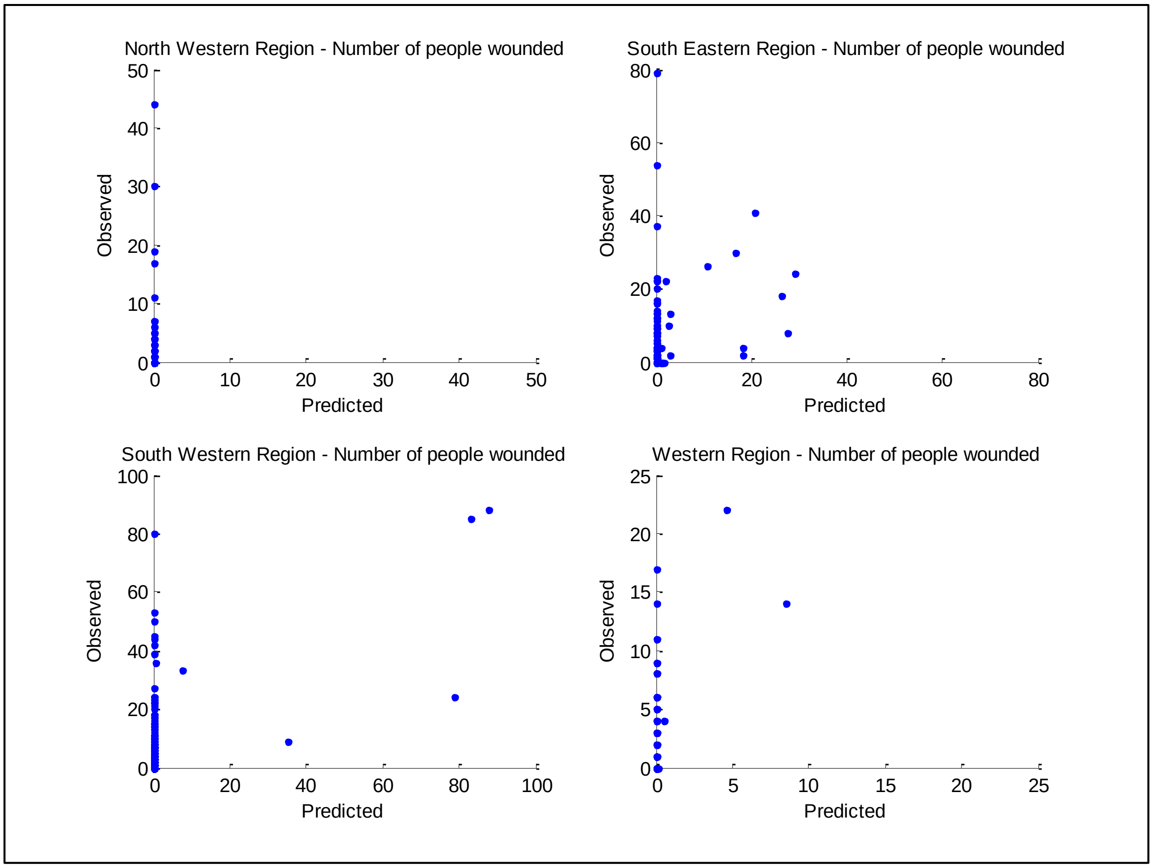


Figure 26: ANN predicted and observed values of number of people wounded for north western, south eastern, south western, and western regions

4.1.3 Prediction of number of people hijacked

Experimental results of configurations for number of people hijacked and each region based on number of neurons in a hidden layer were represented in Table 14. Based on Table 14, the minimum MAE values were highlighted and Table 15 provides information about the best ANN model configuration for number of people hijacked in each region. Based on the information in Table 15, the MAE values vary between 0 and 0.4 for all regions and entire country. Corresponding percentage values of prediction performance vary around 95%. Central, north eastern, south eastern and south western regions had better prediction performance percentage value than Afghanistan. Central region had the best prediction performance accuracy among seven regions, the MAE value was found as 0.1091 and the percentage value of prediction performance was found as 97.576%. On the other side, western region had the worst prediction performance accuracy, the MAE value was calculated as 0.3154 and the percentage value of prediction performance was found as 94.44%

Figure 27 provides information about ANN predicted and observed values of number of people hijacked for Afghanistan and the regions of central, eastern, and north eastern and Figure 28 provides same information type for the regions of north western, south eastern, south western and western.

Table 14: Number of people hijacked – ANN best configuration highlighted for each region based on number of neurons in a hidden layer

	Mean Absolute Error (MAE)							
	Afgh.	**Central**	**Eastern**	**N.East.**	**S.East.**	**Western**	**N.Western**	**S.West.**
1	0.1981	0.1496	0.4830	0.1453	0.4115	0.3199	0.2253	0.3343
2	0.1985	0.1091	0.3002	0.1735	0.2016	0.3154	1.4222	0.1569
3	0.2163	0.1642	0.5905	0.5341	0.5331	0.3718	0.2136	6.4449
4	0.1981	0.1091	0.2872	0.1368	0.2016	0.3313	0.2276	0.1569
5	0.2214	0.3386	0.3155	0.1891	0.7474	0.3439	0.3727	0.3155
6	0.8028	0.3343	2.0758	3.4833	4.8236	5.4331	0.3482	1.6845
7	0.1981	0.1091	0.3901	2.2826	0.5121	0.3154	0.2136	1.0257
8	0.1981	0.1091	0.2867	2.1795	0.2016	0.3154	0.2674	0.1569
9	0.2163	0.8506	5.0699	12.8068	0.3433	0.3706	1.1731	0.4270
10	0.2552	1.5585	0.6221	0.2722	5.5092	11.7265	0.2792	1.6540
11	1.1069	0.6836	14.5276	0.5116	2.9542	0.5332	1.2132	0.4950
12	0.2403	0.2532	8.3643	0.2324	0.8030	0.3547	3.1410	0.2714
13	1.5107	0.3616	10.5916	3.1885	0.2679	0.6046	0.2258	3.5813
14	0.8311	0.4782	1.1431	3.2316	1.3233	4.2016	0.3464	1.6701
15	3.8608	0.1372	0.2873	0.8474	0.3209	0.4912	2.9212	0.4347
16	1.6583	0.1936	0.3636	7.8576	0.9097	2.4894	3.3835	0.4581
17	0.4361	0.1174	0.5217	0.1463	1.0548	0.5298	0.2306	0.9809
18	0.4135	0.2334	0.3659	8.7275	0.3819	0.6019	0.2363	0.1569
19	1.3710	0.1194	0.7342	0.1710	8.3826	0.3344	1.4287	1.0361
20	0.7535	0.5536	4.0367	1.0595	0.3644	2.4834	0.6269	1.1269

	Mean Absolute Error (MAE)							
	Afgh.	**Central**	**Eastern**	**N.East.**	**S.East.**	**Western**	**N.Western**	**S.West.**
21	0.2313	1.6479	0.7813	0.5230	0.5378	0.6865	0.2826	21.2822
22	22.7646	0.2316	9.9911	0.3758	0.2937	0.4431	0.3138	8.0269
23	0.8325	0.3317	0.4414	0.2142	0.3527	0.3453	0.3241	2.7808
24	0.2006	0.2002	0.3678	0.1368	0.2580	0.3573	0.2391	0.2108
25	0.2327	0.1105	0.2994	0.1998	0.2103	0.3302	0.7290	0.2427
26	0.4101	0.9163	6.8361	0.1368	1.6201	0.4939	0.2278	0.9951
27	0.3574	0.1934	0.9242	1.4562	0.5190	1.6796	0.2139	0.2571
28	0.3014	0.1944	1.3393	1.4937	0.2133	0.8782	0.2501	0.7124
29	0.1985	0.1553	0.2867	0.2168	0.9224	0.3154	0.2160	0.1569
30	0.3268	0.1503	0.2867	0.1368	0.3663	0.3154	0.2138	0.1608
31	0.4643	0.9847	0.8447	0.1418	0.6727	0.3154	0.6277	0.2555
32	0.1981	0.1795	0.2987	0.4432	1.9199	0.3354	0.3305	0.6397
33	0.2129	0.1096	0.2867	13.7726	0.2016	0.3154	0.2200	0.2300
34	0.4179	0.2242	1.2405	10.1473	6.6546	0.3621	1.7642	1.7483
35	0.2019	0.2624	8.6942	0.2174	0.5329	0.3450	0.7780	0.1570
36	0.1981	0.1341	0.6125	1.0162	5.6904	1.6274	1.3061	0.6672
37	0.2823	0.1134	0.5241	0.3696	0.2369	0.4279	0.3163	0.1632
38	0.4759	0.6250	0.3634	0.1412	1.7133	0.3378	0.3453	0.1645
39	0.1981	0.1091	0.7392	0.3671	0.2016	2.1419	0.4039	0.1569
40	0.2354	0.2204	0.6088	0.1968	28.1642	1.7358	0.4562	1.0440
41	0.6299	0.2286	0.6549	0.1676	0.5575	0.4914	0.2219	0.1904
42	0.2961	0.2654	0.5977	0.1557	0.5280	0.3486	0.2519	0.8880
43	0.1993	0.4352	0.5592	4.0217	1.3582	0.3377	3.7211	0.7033
44	0.2002	0.1845	0.2868	0.1381	0.2017	2.3612	0.2820	0.1570
45	0.3205	0.1479	2.7203	11.0635	0.7794	0.3161	0.2138	0.3924
46	0.2010	0.1137	10.5612	2.5032	1.2565	0.4598	0.5793	0.3331
47	0.1981	0.1091	0.2867	0.2912	0.2459	0.5114	0.2465	0.9903
48	0.2686	0.1091	0.2868	2.8880	9.9016	0.3234	0.6954	0.1569
49	0.5132	0.1546	0.8292	0.1473	3.7369	0.3583	0.6312	8.2489
50	0.2768	0.1791	0.4136	0.1979	0.3656	0.7848	0.2434	0.8933

Table 15: ANN best model configuration for number of people hijacked in each region

Region	MAE	Prediction performance	Number of neurons in a hidden layer
Afghanistan	0.1981	96.645%	39
Central	0.1091	97.576%	4
Eastern	0.2867	94.166%	47
North Eastern	0.1368	98.134%	30
Western	0.3154	94.444%	30
South Eastern	0.2016	97.715%	2
South Western	0.1569	97.778%	48
North Western	0.2136	95.757%	7

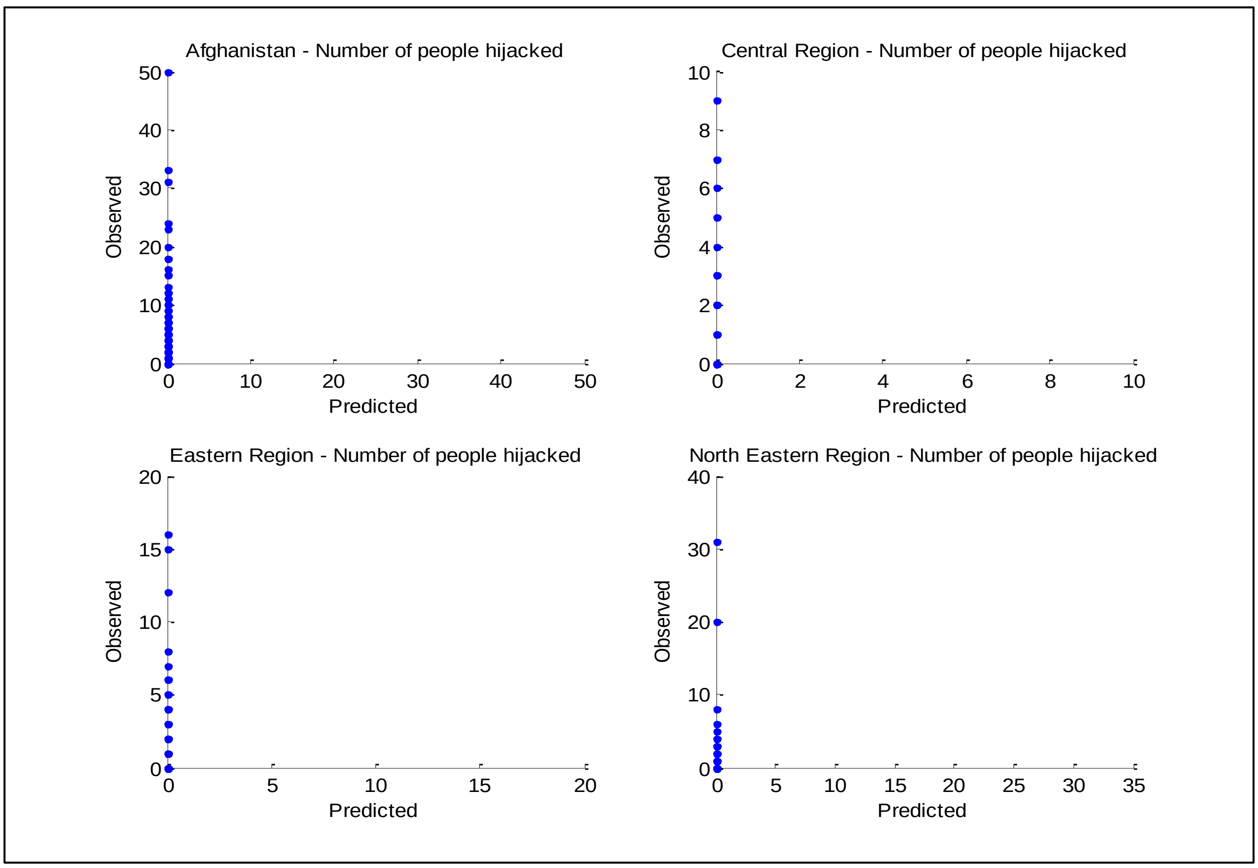


Figure 27: ANN predicted and observed values of number of people hijacked for Afghanistan, central, eastern, and north eastern regions

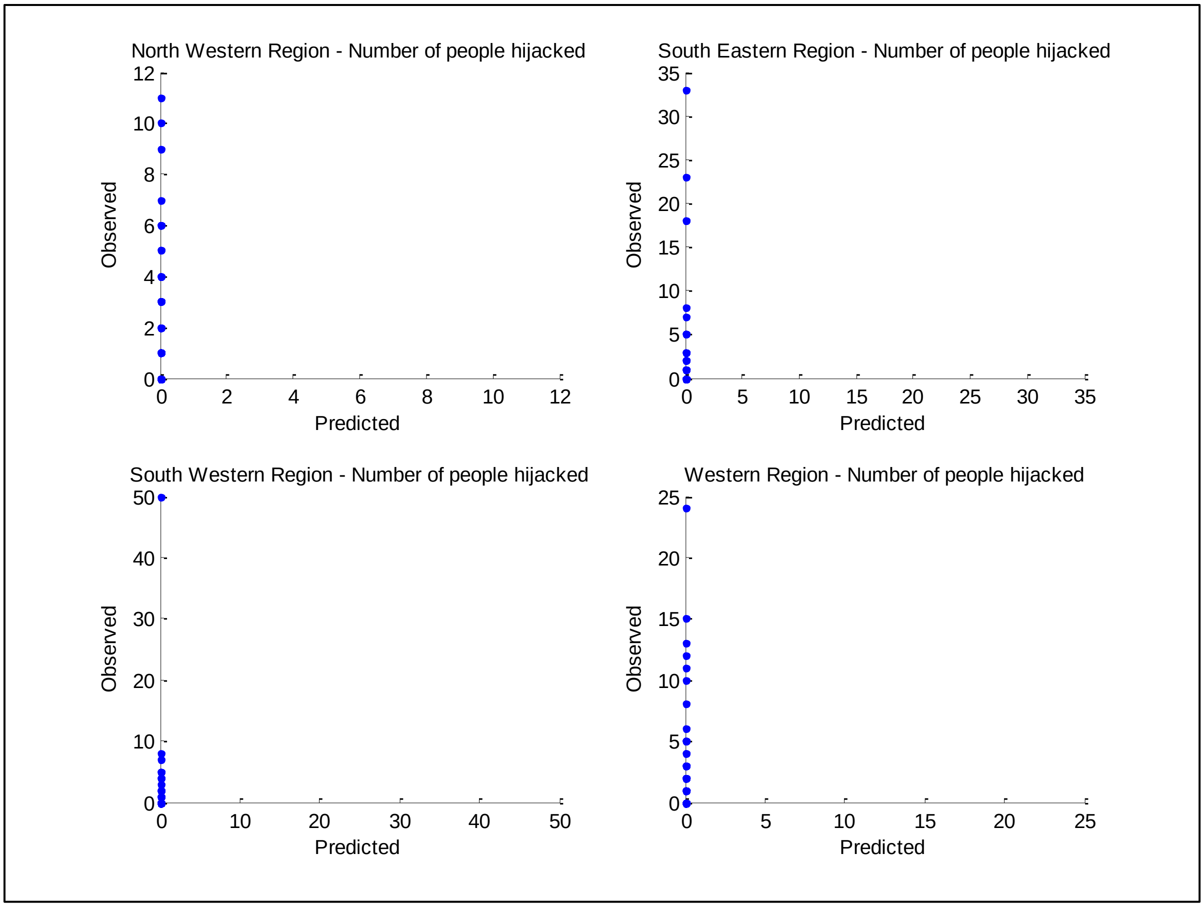


Figure 28: ANN predicted and observed values of number of people hijacked for north western, south eastern, south western, and western regions

4.1.4 Prediction of total number of adverse events

Experimental results of configurations for total number of adverse events and each region based on number of neurons in a hidden layer were represented in Table 16. Based on Table 16, the minimum MAE values were highlighted and Table 17 provides information about the best ANN model configuration for total number of adverse events in each region. Based on the information in Table 17, the MAE values vary between 0 and 1 except for south western region. Corresponding percentage values of prediction performance vary around 90%. Central, eastern, north eastern and north western regions had better prediction performance percentage value than

Afghanistan. North western region had the best prediction performance accuracy among seven regions, the MAE value was found as 0.43 and the percentage value of prediction performance was found as 90.757%. On the other side, south western region had the worst prediction performance accuracy, the MAE value was calculated as 1.1228 and the percentage value of prediction performance was found as 77.36%

Figure 29 provides information about ANN predicted and observed values of total number of adverse events for Afghanistan and the regions of central, eastern, and north eastern and Figure 30 provides same information type for the regions of north western, south eastern, south western and western.

Table 16: Total number of adverse events – ANN best configuration highlighted for each region based on number of neurons in a hidden layer

	Mean Absolute Error (MAE)							
	Afgh.	**Central**	**Eastern**	**N.East.**	**S.East.**	**Western**	**N.West.**	**S.West.**
1	0.6881	0.8165	0.6597	0.4856	1.0477	0.7104	0.4527	1.3486
2	0.6885	0.5545	8.4023	0.3874	0.8819	0.6879	1.6170	1.2722
3	0.6933	6.9140	6.9568	1.8450	0.8021	2.9532	0.4303	1.6357
4	0.6885	0.5564	0.5967	0.3993	1.0525	2.5064	1.3157	1.2373
5	0.6921	0.5359	0.8387	0.4112	0.8758	1.0935	0.6191	1.2513
6	0.7235	0.5176	0.8676	0.3916	0.9870	0.6778	1.0234	1.1553
7	0.6823	0.5545	0.6367	0.3993	1.1311	0.6879	0.4317	1.2839
8	0.6885	0.8712	0.5817	2.1911	1.0608	0.6879	0.7261	1.2722
9	0.8717	0.5604	0.9991	2.2287	0.9326	0.8099	1.9179	1.3376
10	0.7088	0.6000	0.6464	0.4131	0.9762	12.6517	0.4755	1.1652
11	0.9460	0.5468	0.6039	0.4027	0.9514	0.7604	1.1723	1.2008
12	0.9782	0.7631	0.6413	0.4684	3.0228	0.6590	3.2568	1.1292
13	0.8189	1.0524	0.9849	0.6172	1.0890	0.8312	0.4303	1.5963
14	0.8410	0.6171	0.5966	0.4572	0.8260	0.6655	0.4508	1.3224
15	0.6833	1.5995	1.9283	0.4024	0.9825	1.4320	0.4579	1.9189
16	0.6655	0.5820	0.6012	0.4799	0.8712	0.7380	0.4303	1.1228
17	0.7443	0.5738	0.5966	2.1377	0.8288	0.6776	0.5234	1.4925
18	0.9917	1.1491	0.7334	1.9805	1.0720	0.6950	1.6165	1.5649
19	0.6954	0.8319	0.6681	0.4705	0.8398	0.8188	0.4303	1.1844
20	0.6885	0.7898	1.1122	0.4455	0.8468	0.8069	0.4639	1.2444

	Mean Absolute Error (MAE)							
	Afgh.	**Central**	**Eastern**	**N.East.**	**S.East.**	**Western**	**N.West.**	**S.West.**
21	0.6925	0.8164	0.6113	0.4828	0.8792	0.7162	1.0929	1.4398
22	0.8797	2.9948	5.8872	0.3959	0.8364	2.1139	0.4303	1.7597
23	0.8095	1.1279	0.6178	0.4901	1.0221	0.7195	1.4503	3.2479
24	0.7030	0.8029	0.5744	0.3998	0.8763	0.6770	0.7414	2.9322
25	0.6870	1.2142	0.7565	1.1501	0.9218	0.6762	2.5470	1.3048
26	0.7315	0.8879	1.0352	0.5174	1.2489	0.7351	0.9982	1.2888
27	0.6793	0.5471	0.5648	0.3794	0.8601	0.6821	0.6308	1.2288
28	0.6999	1.0354	0.6731	0.3986	0.8559	0.6836	0.7298	1.3214
29	0.7183	0.9310	0.8735	0.3993	1.0806	0.6879	0.4921	1.3167
30	0.6885	0.5545	1.2243	0.4030	1.0943	0.6879	3.5957	1.2722
31	0.6712	0.5751	0.5676	0.4064	4.5058	0.8136	0.5922	1.2337
32	0.6887	0.4991	0.9088	0.4355	0.8703	0.6830	0.5572	1.3266
33	0.7110	0.7424	2.6182	2.9228	0.9448	0.6879	0.5413	1.2722
34	0.6847	0.6249	0.9494	0.3887	0.8954	0.7225	0.4309	1.5109
35	0.7345	0.5208	0.5818	0.4487	0.8710	2.8804	0.6980	1.4279
36	1.3752	0.5728	1.5598	0.4267	0.8725	0.6891	0.9882	1.2724
37	0.6810	1.2742	0.7466	0.8971	1.2805	0.6755	0.4617	2.2844
38	1.1963	0.6684	0.9269	0.4023	1.2083	0.7066	0.4512	1.3517
39	0.9184	0.6372	0.6849	0.6219	0.9857	0.6866	1.8266	1.2722
40	0.6587	0.5273	0.6289	0.4082	0.9477	0.7535	0.4373	1.6640
41	0.6805	0.5788	0.6548	0.5054	0.9919	0.6743	0.4396	1.2496
42	0.6678	0.5636	3.3181	1.7954	1.0575	0.6776	0.4678	1.7245
43	0.6988	0.8883	2.1443	0.7734	0.8637	1.0398	0.4303	1.3296
44	5.2623	0.5924	0.6029	0.4459	0.8771	1.3117	0.4334	1.2877
45	0.7836	0.7235	1.2083	0.5023	0.9151	0.7069	0.4303	1.1938
46	0.7001	0.6485	0.5816	0.5302	0.8621	4.9625	0.6513	1.2627
47	0.6885	0.7473	0.5817	0.4353	0.9032	0.7070	2.6988	1.3611
48	1.6498	0.5546	0.7221	0.8117	1.7840	0.8125	1.7200	3.0836
49	0.7079	0.7337	0.6402	0.4004	1.0972	5.2469	0.5900	1.7468
50	0.8403	0.8426	0.6895	0.4032	0.8736	0.7706	0.5424	2.8199

Table 17: ANN best model configuration for total number of adverse events in each region

Region	MAE	Prediction performance	Number of neurons in a hidden layer
Afghanistan	0.6587	86.251%	40
Central	0.4991	89.545%	32
Eastern	0.5648	87.667%	27
North Eastern	0.3794	89.553%	27
Western	0.6590	85.621%	12
South Eastern	0.8021	84.811%	3
South Western	1.1228	77.361%	16
North Western	0.4303	90.757%	43

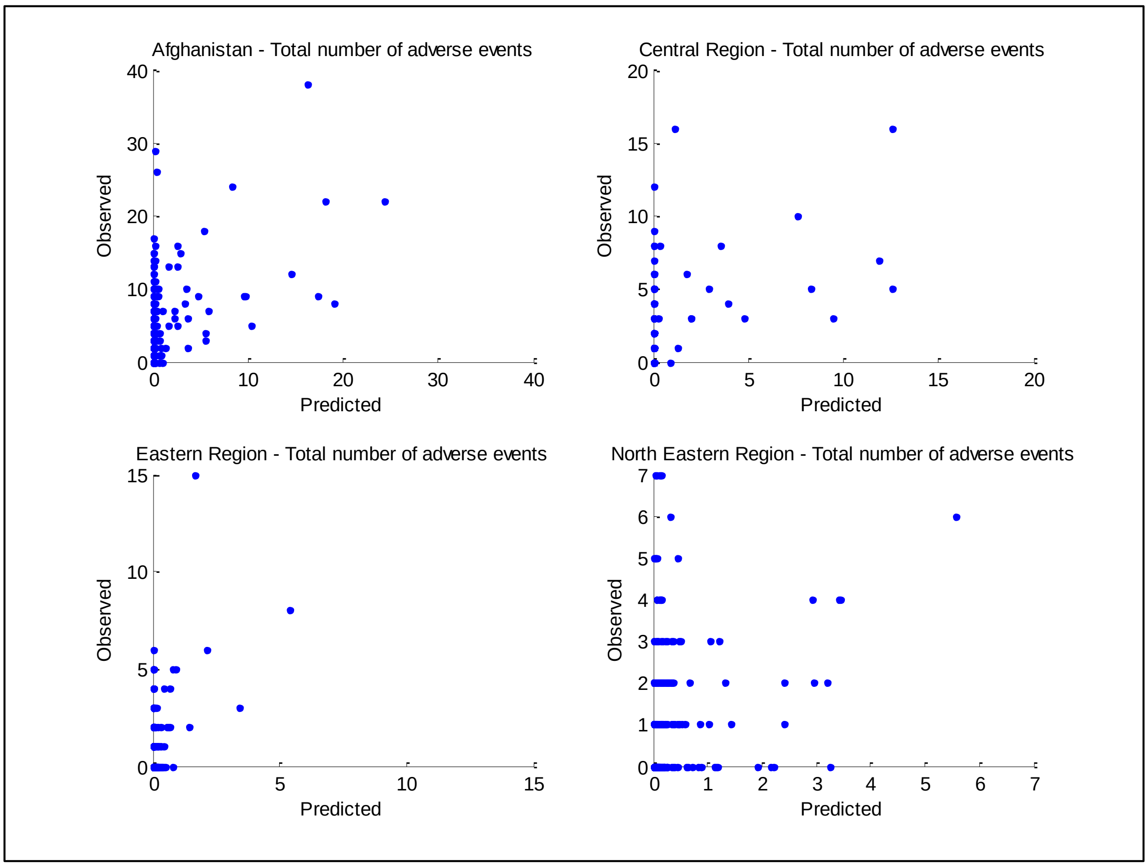


Figure 29: ANN predicted and observed values of number of total adverse events for Afghanistan, central, eastern, and north eastern regions

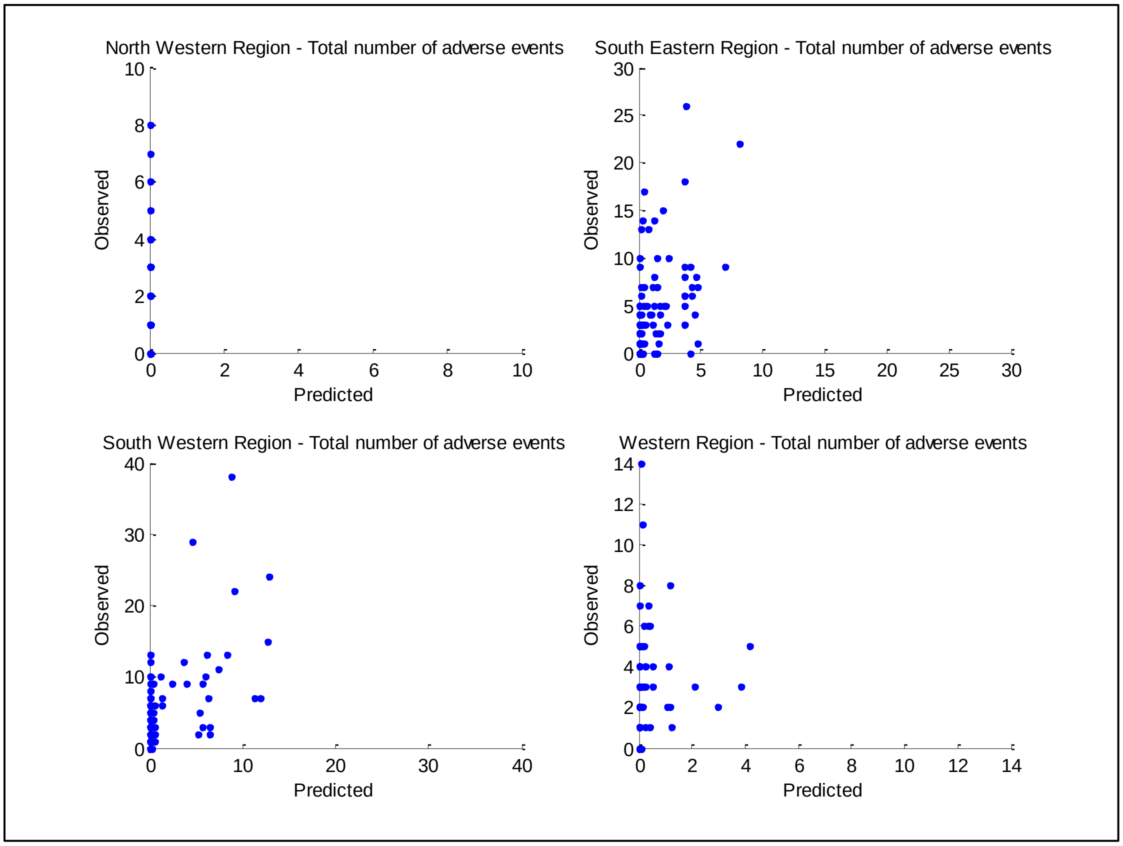


Figure 30: ANN predicted and observed values of number of total adverse events for north western, south eastern, south western, and western regions

4.2 FIS Model Development

For the models developments, we generated fuzzy inference systems using fuzzy c-means (FCM) and subtractive clustering algorithms. To compare the performances of FIS models with other two methodologies on the same basis, divided sets of dependent and independent variables were categorized according to the training and testing data division in previous section. Therefore, the same percentages (85.71% for constructing FIS and 14.29% for testing) were also used for the FIS models. To generate FIS models from data using FCM algorithm, the MATLAB function "genfis3" was used. The parameters of "genfis3" function (input data, output data, and type of FIS) generate a 'mamdani' or 'sugeno' FIS structure. In this research, we selected ‘mamdani’ type that gave less MAE values than ‘sugeno’ type. The amount of clusters identifies the amount of rules and membership functions in the created FIS. In this research, the number of clusters varies from 1 to 300. FIS experimental results of all configurations based on dependent variables and regions were represented in following sections. All membership functions were selected as Gaussian type membership functions. For instance, number of clusters of number of people killed dependent variable for central region was calculated as 6 based on the minimum MAE value. Therefore, number of membership functions and rules of all independent and dependent variables are equal to 6 for this model. The Gaussian membership functions and associated rules of one of the independent variables of this model are illustrated in Figure 31 and Figure 32.

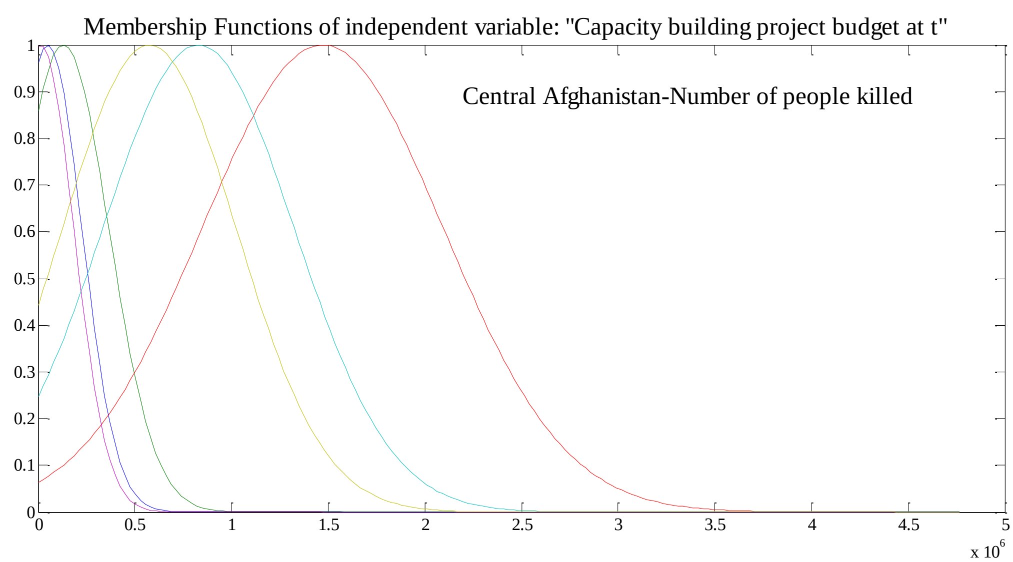


Figure 31: Illustration of membership functions when number of clusters equals to six

1. If (in1 is in1cluster1) and (in2 is in2cluster1) and (in3 is in3cluster1)
2. If (in1 is in1cluster2) and (in2 is in2cluster2) and (in3 is in3cluster2)
3. If (in1 is in1cluster3) and (in2 is in2cluster3) and (in3 is in3cluster3)
4. If (in1 is in1cluster4) and (in2 is in2cluster4) and (in3 is in3cluster4)
5. If (in1 is in1cluster5) and (in2 is in2cluster5) and (in3 is in3cluster5)
6. If (in1 is in1cluster6) and (in2 is in2cluster6) and (in3 is in3cluster6)

Figure 32: Illustration of rule number when number of clusters equals to six

For some cases, the FCM algorithm did not perform very well, therefore the subtractive clustering algorithm was applied for the south western region of two dependent variables: number of people killed and wounded. To create a FIS model from the dataset using subtractive clustering, the MATLAB function “genfis2” was used. This function needs a cluster radius to be specified. A small cluster radius results in many small clusters and many rules. On the contrary, a large cluster radius results in few large clusters and few rules. We assigned a cluster radius of 0.1 that gives the minimum MAE value.

4.2.1 Prediction of number of people killed

Experimental results of configurations for number of people killed and each region based on number of clusters were represented in Table 18. Based on Table 18, the minimum MAE values were highlighted and Table 19 provides information about the best FIS model configuration for number of people killed in each region. Based on the information in Table 19, the MAE values vary between 0 and 2 except for south western region and entire country. Corresponding percentage values of prediction performance vary around 90%. All regions except south western had better prediction performance percentage value than Afghanistan. North western region had the best prediction performance accuracy among seven regions, the MAE value was found as 0.44 and the percentage value of prediction performance was found as 94.09%. On the other side, south western region had the worst prediction performance accuracy, the MAE value was calculated as 2.0278 and the percentage value of prediction performance was found as 76.94%

Figure 33 provides information about FIS predicted and observed values of number of people killed for Afghanistan and the regions of central, eastern, and north eastern and Figure 34 provides same information type for the regions of north western, south eastern, south western and western.

Table 18: Number of people killed – FIS best configuration for each region based on number of cluster

Cluster number	**Mean Absolute Error (MAE)**						
	Afgh.	**Central**	**Eastern**	**N.Eastern**	**S.Eastern**	**Western**	**N.Western**
1	50.8344	21.4667	11.2283	39.1182	15.2567	13.4820	3.4766
2	2.4937	1.4533	1.6539	0.6435	2.6704	1.7412	0.7580
3	2.8523	1.3461	1.8548	0.6421	2.4648	1.9607	0.8165
4	2.8607	1.3197	1.0872	0.6336	2.4687	1.8727	0.9173
5	2.1518	1.4883	1.0455	0.6283	2.0145	1.3898	0.5036
6	2.1950	1.1566	0.9798	0.8658	1.9506	1.3824	0.5016
7	2.2668	1.3010	0.9786	0.9697	1.9313	1.4525	0.4978
8	2.4595	1.3181	1.0479	1.1710	1.9017	1.4422	0.4986
9	2.2908	1.3376	1.0090	1.1703	2.0319	1.4350	0.5237
10	2.2850	1.3318	1.0023	1.4350	2.0096	1.4342	0.5401
11	2.2846	1.6376	0.9989	1.1645	2.0523	1.6358	0.5087
12	2.3023	1.6160	0.9994	1.3801	1.9913	1.3736	0.5386
13	2.3256	1.5177	1.0591	1.4325	1.9092	1.5772	0.5727
14	2.3139	1.6442	1.0515	1.4322	1.8987	1.4000	0.6015
15	2.3129	1.5334	1.0133	1.3891	2.1749	1.6060	0.5942
16	2.5581	1.7179	0.9879	1.4106	2.1778	1.6120	0.6162

Cluster number	Mean Absolute Error (MAE)						
	Afgh.	Central	Eastern	N.Eastern	S.Eastern	Western	N.Western
17	2.5197	1.6868	0.9952	1.3893	2.2274	1.6225	0.5978
18	2.5824	1.5480	0.9977	1.3358	2.2897	1.4422	0.5911
19	2.5176	1.5533	0.9750	1.3788	2.0761	1.4045	0.5550
20	2.5247	1.5602	0.9752	1.3900	2.1125	1.5955	0.5981
21	2.3223	1.5799	0.9740	1.6019	2.2902	1.6305	0.5176
22	2.3131	1.7146	0.9539	1.5674	2.4314	1.6015	0.5303
23	2.5697	1.5359	0.9946	1.5613	2.4230	1.5774	0.5448
24	2.3496	1.4703	0.9163	1.5675	2.4169	1.4033	0.5206
25	2.5512	1.7255	0.8387	1.7136	2.4820	1.5998	0.5276
26	2.6367	1.9864	0.9034	1.6548	2.4548	1.6062	0.5524
27	2.5818	1.9911	0.9340	1.6527	2.4657	1.5456	0.5262
28	2.6136	1.9548	0.9762	1.3034	2.5035	1.5342	1.3065
29	2.3104	1.9545	0.9284	1.3802	2.4848	1.5050	1.2567
30	2.6198	1.7045	0.9482	1.7198	2.3303	1.5793	0.5197
31	2.2012	1.9590	0.8860	1.3092	2.4800	1.5243	1.2963
32	2.2112	2.0105	0.9080	1.6508	2.4611	1.5486	1.2948
33	2.5054	1.8711	0.9210	1.3067	2.0186	1.4473	0.5795
34	2.5694	1.9642	0.9460	1.6548	2.3288	1.4728	1.2442
35	2.3532	1.9605	0.9223	1.4240	2.3341	1.4183	0.4568
36	2.3554	1.9665	0.9116	1.6990	2.5606	1.4400	0.4419
37	2.5089	1.9745	1.2769	1.5345	1.8006	1.4311	0.4973
38	2.5937	2.0135	0.9107	1.4221	1.8564	1.4375	0.5826
39	2.4660	2.0119	0.7458	1.4281	1.7689	1.3386	1.2068
40	2.5099	1.9688	0.9742	1.4243	1.8044	1.4391	0.5804
41	2.4753	1.8593	0.9389	1.4262	2.3977	1.4437	0.5429
42	2.4970	2.0298	0.8761	1.2389	1.6468	1.4516	0.5315
43	2.4479	2.0221	0.7739	1.4278	2.0347	1.4560	0.5490
44	2.5531	2.0197	0.8931	1.5618	1.6120	1.3213	0.5793
45	2.4606	1.9740	0.9103	1.2502	1.9842	1.4098	1.2478
46	2.4775	2.0089	0.8484	1.2343	2.0578	1.4628	0.5866
47	2.6671	1.9282	1.0221	1.2464	1.7008	1.3051	0.4787
48	2.5568	1.4630	0.9787	1.4338	1.7359	1.3467	0.5446
49	2.4983	1.9330	0.8615	1.2616	1.7979	1.3109	0.5703
50	2.4870	1.8440	1.0862	1.5554	1.5678	1.4018	1.2693
79					1.5003		
300	2.1770						

*South Western region was analyzed using subtractive clustering with radii 0.1 and the corresponding MAE value was calculated 2.0278

Table 19: FIS best model configuration for number of people killed in each region

Region	MAE	Prediction performance	Number of clusters
Afghanistan	2.1770	81.437%	300
Central	1.1566	84.242%	6
Eastern	0.7458	91.166%	39
North Eastern	0.6238	91.044%	5
Western	1.3051	81.536%	47
South Eastern	1.5004	83.199%	79
South Western	2.0278	76.944%	Radii: 0.1
North Western	0.4419	94.091%	36

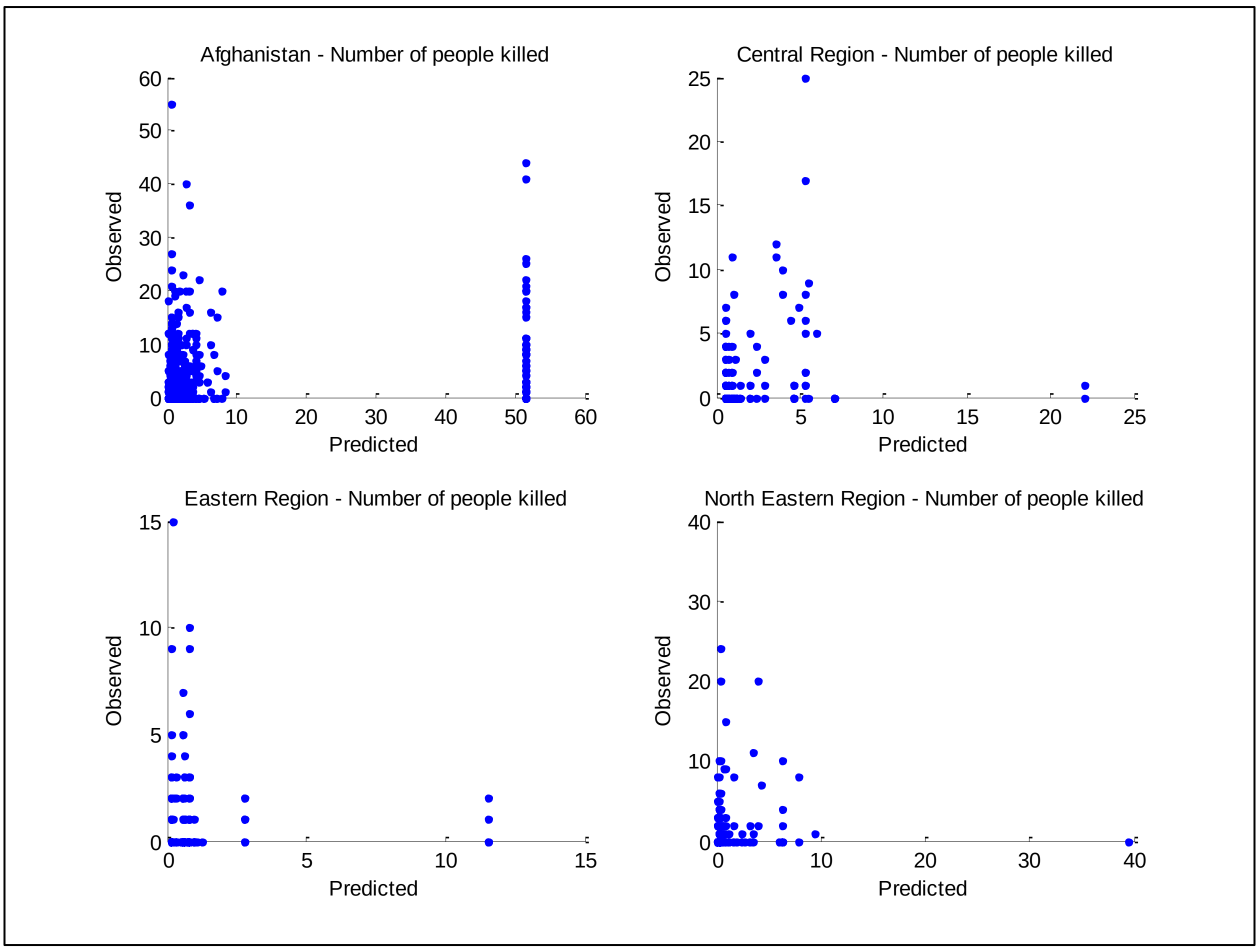


Figure 33: FIS predicted and observed values of number of people killed for Afghanistan, central, eastern, and north eastern regions

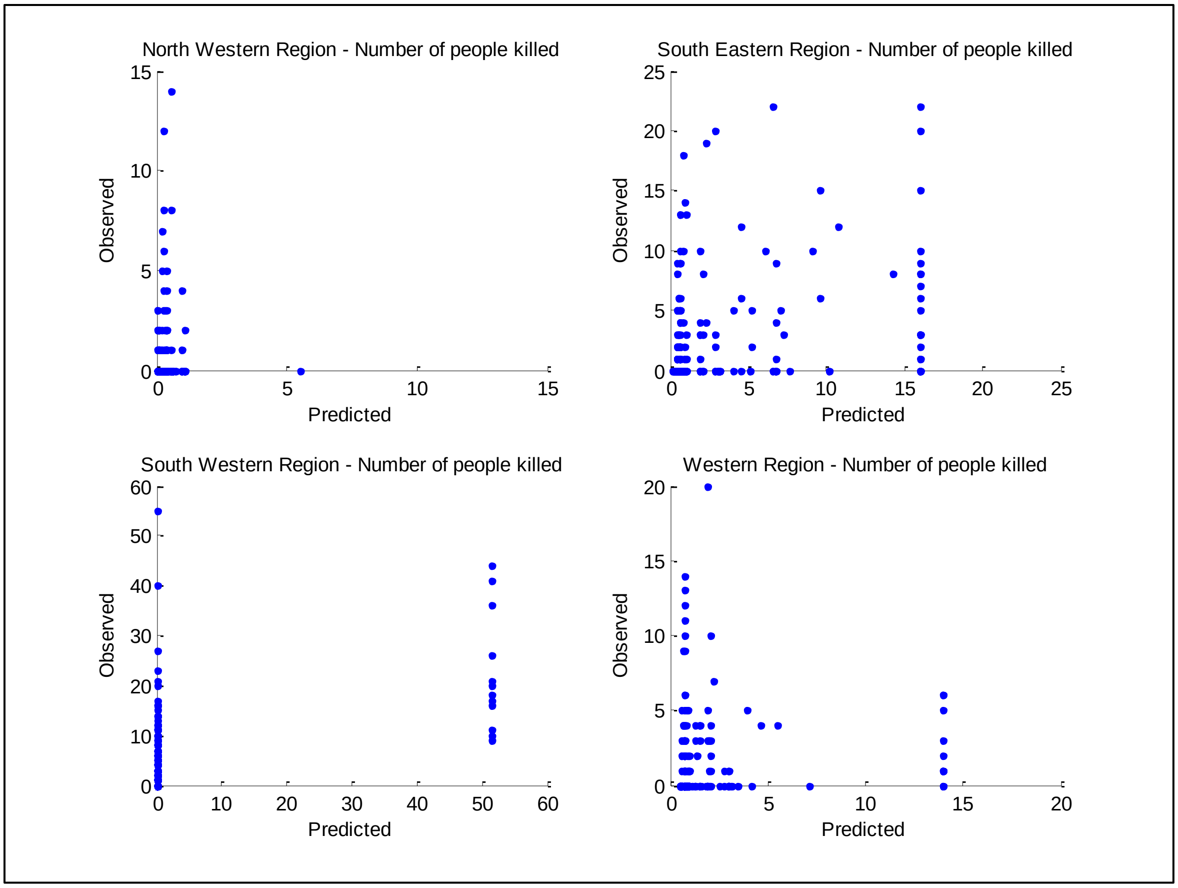


Figure 34: FIS predicted and observed values of number of people killed for north western, south eastern, south western, and western regions

4.2.2 Prediction of number of people wounded

Experimental results of configurations for number of people wounded and each region based on number of clusters were represented in Table 20. Based on Table 20, the minimum MAE values were highlighted and Table 21 provides information about the best FIS model configuration for number of people wounded in each region. Based on the information in Table 21, the MAE values vary between 0 and 3 except for central region and entire country. Corresponding percentage values of prediction performance vary around 80%. North eastern, south western, and north western regions had better prediction performance percentage value than Afghanistan. North western region had the best prediction performance accuracy among seven regions, the MAE value was found as 0.569 and the percentage value of prediction performance was found as 92.87%. On the other side, central region had the worst prediction performance accuracy, the MAE value was calculated as 4.93 and the percentage value of prediction performance was found as 71.06%

Figure 35 provides information about FIS predicted and observed values of number of people wounded for Afghanistan and the regions of central, eastern, and north eastern and Figure 36 provides same information type for the regions of north western, south eastern, south western and western.

Table 20: Number of people wounded – FIS best configuration for each region based on number of cluster

Cluster number	**Mean Absolute Error (MAE)**						
	Afgh.	**Central**	**Eastern**	**N.Eastern**	**S.Eastern**	**Western**	**N.Western**
1	129.4950	84.270	129.525	47.912	14.2982	23.4477	7.7939
2	4.4381	5.774	3.443	1.067	3.7284	1.9222	0.9787
3	4.9321	5.478	3.898	1.072	3.4631	2.1811	1.0456
4	4.9460	5.414	3.216	1.053	3.4913	2.0822	1.1352
5	4.9487	5.668	2.956	1.044	2.9077	1.5684	0.8407
6	4.3322	5.841	3.252	1.202	2.8463	1.5788	0.8436
7	4.3564	5.243	3.254	1.265	2.8149	1.5228	0.8048
8	4.6026	5.295	4.000	1.363	2.7477	1.5285	0.7613
9	4.5783	5.313	3.697	1.363	2.9152	1.5284	0.7779
10	4.5789	5.300	3.688	1.375	2.8649	1.5262	0.7240
11	4.4738	5.622	3.695	1.298	2.9294	1.7324	0.7384
12	4.4250	5.544	3.695	1.357	2.8482	1.5474	0.7551
13	4.5327	5.219	3.830	1.307	2.7684	1.5524	0.7045
14	4.4113	5.615	3.808	1.307	2.7472	1.4971	0.7278
15	4.5259	5.274	3.632	1.189	3.1768	1.6207	0.7112
16	4.7454	5.865	3.422	1.252	3.1216	1.6398	0.7462
17	4.6565	5.769	3.447	1.189	3.1971	1.6444	0.7453

Cluster number	Mean Absolute Error (MAE)						
	Afgh.	Central	Eastern	N.Eastern	S.Eastern	Western	N.Western
18	4.7928	5.447	3.458	1.194	3.3796	1.5600	0.7094
19	4.6685	5.423	3.340	1.243	2.9537	1.5055	0.7109
20	4.8531	5.410	3.526	1.190	3.0865	1.5969	0.7305
21	4.4961	5.376	3.433	1.198	3.3595	1.6435	0.6936
22	4.3864	5.819	3.417	1.199	3.5927	1.5856	0.6561
23	4.9319	5.427	3.507	1.239	3.5604	1.5749	0.7238
24	4.3520	5.286	3.346	1.199	3.5026	1.5005	0.7231
25	4.8576	5.817	3.233	1.436	3.6331	1.5800	0.6859
26	5.1104	6.060	3.363	1.408	3.5659	1.5839	0.6994
27	5.1265	6.079	3.429	1.403	3.5837	1.5838	0.6756
28	5.2008	6.107	3.429	1.365	3.8854	1.5696	1.4630
29	4.3910	5.936	3.413	1.311	3.8177	1.6040	1.4270
30	5.2557	5.182	3.346	1.443	3.6388	1.6560	0.6303
31	4.4977	6.064	3.328	1.367	3.6228	1.5257	1.5203
32	4.3872	6.155	3.282	1.456	3.7774	1.6493	1.4578
33	4.9810	5.589	3.335	1.368	3.2456	1.5950	0.7508
34	5.0287	6.002	3.257	1.461	3.6608	1.5920	1.4434
35	4.6289	5.950	3.094	1.314	3.5972	1.4940	0.5694
36	4.7082	5.966	2.898	1.456	3.9233	1.5611	0.5745
37	5.1179	6.075	3.380	1.460	2.9977	1.8762	0.6209
38	5.2161	6.140	3.270	1.305	3.0504	1.5560	0.7529
39	5.0047	6.134	3.358	1.370	2.9375	1.4825	1.4111
40	5.0163	5.972	3.240	1.367	2.8866	1.8994	0.7526
41	4.9853	5.733	3.406	1.368	3.7132	1.8789	0.7144
42	5.1353	6.209	2.789	1.340	2.7812	1.9226	0.7202
43	4.9630	6.183	3.320	1.247	3.2119	1.9249	0.7123
44	5.1676	6.170	3.102	1.308	2.7407	1.5427	0.7499
45	5.1051	5.998	3.074	1.426	3.1199	1.7660	1.4496
46	4.9503	6.125	2.760	1.374	3.2113	1.9158	0.7545
47	5.1363	5.731	4.457	1.388	2.8310	1.5640	0.6269
48	5.1862	5.069	3.358	1.325	2.8816	1.7812	0.7234
49	5.1417	5.998	2.986	1.421	2.8394	1.5464	0.7663
50	5.0391	5.726	3.135	1.396	2.7075	1.7345	1.4986
178		4.93					
250					2.3699		
300	4.30		2.6807				

*South Western region was analyzed using subtractive clustering with radii 0.1 and the corresponding MAE value was calculated 2.0806

Table 21: FIS best model configuration for number of people wounded in each region

Region	**MAE**	**Prediction performance**	**Number of clusters**
Afghanistan	4.3022	74.375%	300
Central	4.9301	71.061%	178
Eastern	2.6807	72.166%	300
North Eastern	1.0443	89.303%	5
Western	1.4825	71.079%	39
South Eastern	2.3699	72.043%	250
South Western	2.0806	78.889%	Radii: 0.1
North Western	0.5694	92.878%	35

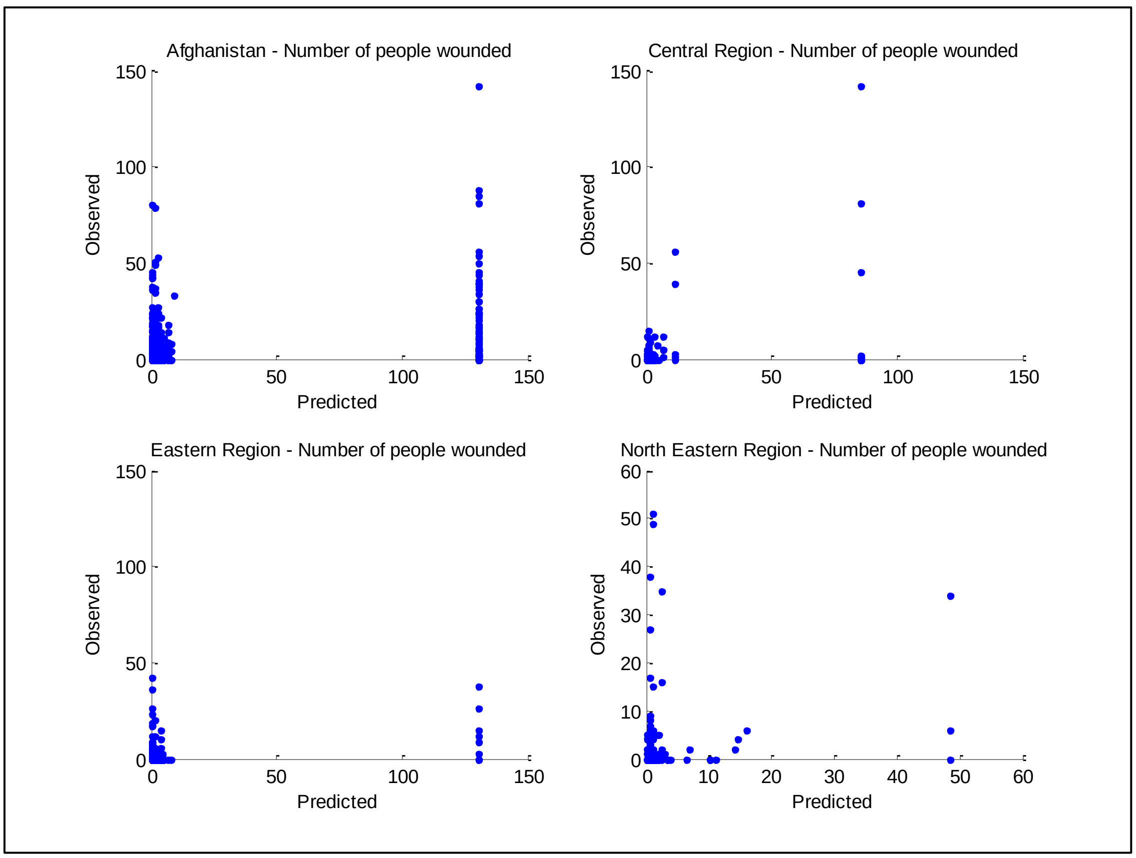


Figure 35: FIS predicted and observed values of number of people wounded for Afghanistan, central, eastern, and north eastern regions

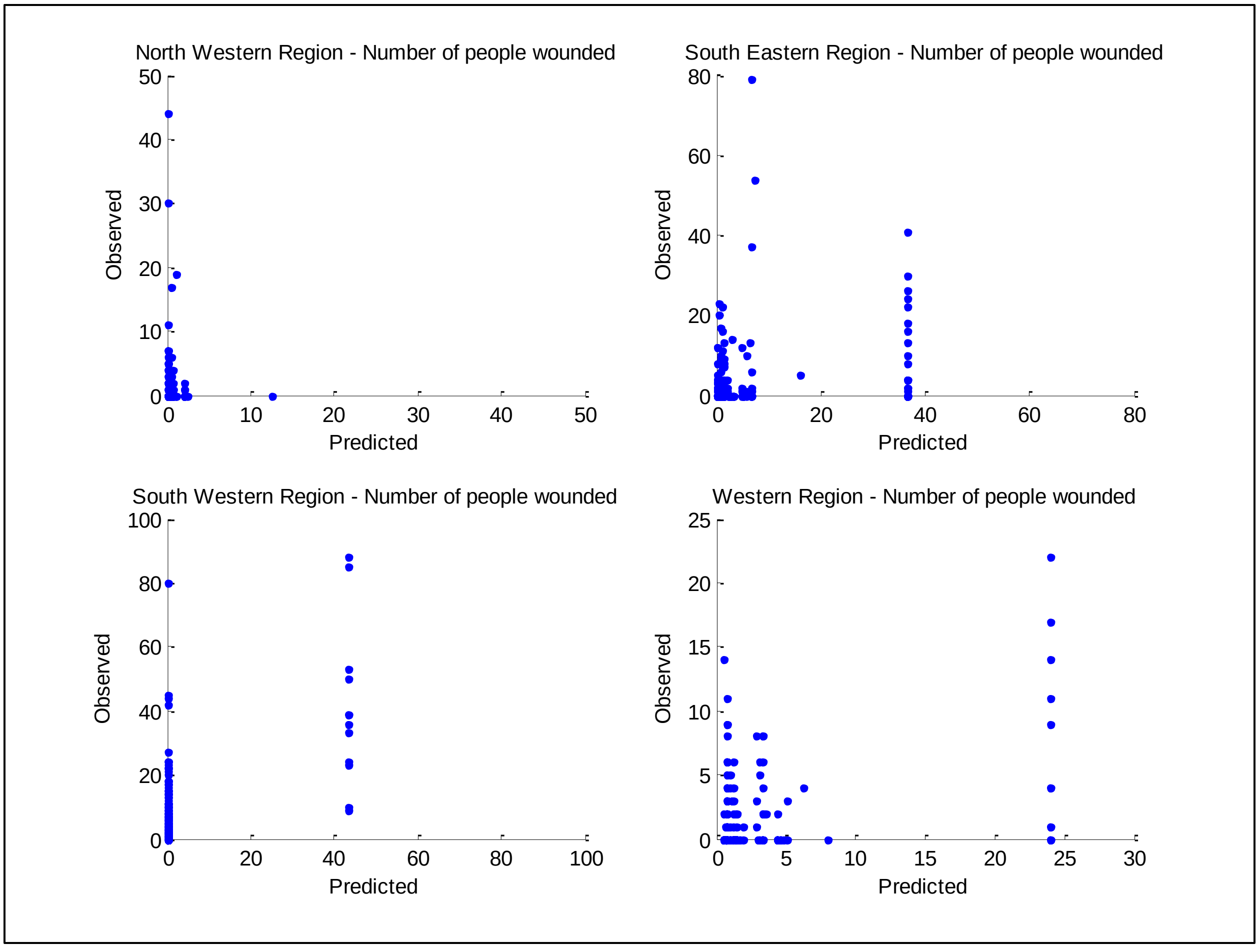


Figure 36: FIS predicted and observed values of number of people wounded for north western, south eastern, south western, and western regions

4.2.3 Prediction of number of people hijacked

Experimental results of configurations for number of people hijacked and each region based on number of clusters were represented in Table 22. Based on Table 22, the minimum MAE values were highlighted and Table 23 provides information about the best FIS model configuration for number of people hijacked in each region. Based on the information in Table 23, the MAE values vary between 0 and 1 for all regions and entire country. Corresponding percentage values of prediction performance vary around 92%. North eastern and north western regions had better prediction performance percentage value than Afghanistan. North eastern region had the best prediction performance accuracy among seven regions, the MAE value was found as 0.2356 and the percentage value of prediction performance was found as 96.26%. On the other side, south eastern region had the worst prediction performance accuracy, the MAE value was calculated as 0.64 and the percentage value of prediction performance was found as 92.07%

Figure 37 provides information about FIS predicted and observed values of number of people hijacked for Afghanistan and the regions of central, eastern, and north eastern and Figure 38 provides same information type for the regions of north western, south eastern, south western and western.

Table 22: Number of people hijacked – FIS best configuration for each region based on number of cluster

Cluster number	Mean Absolute Error (MAE)							
	Afgh.	**Central**	**Eastern**	**N.East.**	**S.East.**	**Western**	**N.West.**	**S.West.**
1	77.8019	4.3212	8.2717	4.9751	19.8414	77.6846	3.0348	17.9319
2	0.5051	0.4718	0.7004	0.2525	0.8597	1.0346	0.3600	0.6942
3	0.5481	0.4799	0.7523	0.2587	0.7406	1.1942	0.3696	0.8107
4	0.5536	0.4798	0.6251	0.2586	0.7602	1.1576	0.3881	0.7807
5	0.5503	0.6289	0.5778	0.2577	0.6552	0.8998	0.4332	0.5926
6	1.8506	0.3982	0.6290	0.2356	0.6587	0.9441	0.4335	0.6320
7	1.8582	0.5400	0.6261	0.3035	0.6444	1.0536	0.3654	0.9302
8	2.2510	0.5596	0.6428	0.2865	0.7927	1.1773	0.3650	0.8551
9	1.8734	0.5758	0.6128	0.2865	0.7691	1.1788	0.3656	0.8614
10	1.8432	0.5762	0.6114	0.2941	0.7704	1.1814	0.3659	0.8608
11	1.7282	0.6823	0.6106	0.2875	0.7707	2.7561	0.3657	0.8620
12	1.7288	0.6697	0.6105	0.2914	0.6896	1.1441	0.3670	0.6782
13	1.7644	0.5881	0.6282	0.2938	0.6914	1.2719	0.3839	0.8649
14	1.7622	0.6848	0.6252	0.2939	0.6820	1.1711	0.3837	0.8664
15	1.7637	0.5997	0.5968	0.2918	0.7576	2.6540	0.3819	0.7052
16	2.1502	0.7033	0.5886	0.2981	0.7244	2.6776	0.3861	0.7257
17	2.1504	0.7148	0.5905	0.2926	0.7278	2.7576	0.3821	0.7177

Cluster number	Mean Absolute Error (MAE)							
	Afgh.	**Central**	**Eastern**	**N.East.**	**S.East.**	**Western**	**N.West.**	**S.West.**
18	2.1825	0.5846	0.5918	0.2838	0.8528	1.1744	0.3798	0.7393
19	2.1514	0.5863	0.5777	0.2983	0.7526	1.0394	0.4389	0.7398
20	2.2162	0.5888	0.5746	0.2936	0.7516	2.7033	0.3804	0.7408
21	1.9588	0.6036	0.5610	0.3001	0.8173	2.8016	0.4351	0.7347
22	1.9877	0.7144	0.5620	0.2843	0.9257	2.7952	0.4333	0.7356
23	2.4029	0.5881	0.5653	0.2935	0.8605	2.7722	0.4384	0.7338
24	2.0074	0.5431	0.5474	0.2843	0.8700	1.1752	0.4317	0.6842
25	2.3933	0.7180	0.5928	0.2915	0.9507	2.8372	0.4337	0.8706
26	2.3889	0.7960	0.5353	0.2917	0.8766	2.8234	0.4364	0.9027
27	2.4112	0.8064	0.4757	0.2904	0.8927	2.7568	0.4301	0.7932
28	3.1223	0.7928	0.5218	0.3364	1.2106	2.7330	0.4315	0.6623
29	3.2232	0.7910	0.5372	0.3005	1.1831	2.7091	0.4318	0.7932
30	2.8798	0.6520	0.5599	0.2916	1.0949	2.8384	0.4298	0.6524
31	3.2111	0.7923	0.5291	0.3370	0.9078	2.8874	0.4389	0.7873
32	2.7322	0.7943	0.5299	0.2900	1.1147	2.7903	0.3804	0.8020
33	3.2344	0.7505	0.5231	0.3430	1.1404	2.6361	0.4351	0.7258
34	3.2111	0.7948	0.5344	0.2900	1.3737	2.6606	0.4333	0.8220
35	3.5454	0.7959	0.5277	0.3431	1.6560	2.7051	0.4384	0.8175
36	4.1222	0.7967	0.5365	0.2897	1.7020	2.6030	0.4317	0.6990
37	4.2215	0.7951	0.5709	0.3496	1.0352	2.1010	0.4337	0.8105
38	4.1854	0.7955	0.5600	0.3418	1.1090	2.5742	0.4364	0.8126
39	4.0987	0.7952	0.5579	0.3413	1.0298	2.0838	0.4301	0.6992
40	4.3223	0.7969	0.5176	0.3384	1.0815	2.1017	0.4315	0.7695
41	3.9899	0.8287	0.5778	0.3428	1.6472	2.0861	0.4318	0.6855
42	4.7334	0.8053	0.4751	0.3276	1.0245	2.0973	0.4298	0.8255
43	4.5447	0.8121	0.4679	0.3450	1.2184	2.1083	0.3839	0.6913
44	4.8776	0.8158	0.4908	0.3370	0.9684	2.4110	0.3837	0.7734
45	4.1234	0.8035	0.4412	0.3386	1.2592	2.1402	0.3819	0.7761
46	4.2232	0.8143	0.4765	0.3271	1.5154	2.0935	0.3861	0.8080
47	4.3213	0.7547	0.6814	0.3390	1.2709	2.0777	0.3821	0.7794
48	4.3323	0.6098	0.5323	0.3429	1.2853	0.6893	0.3798	0.8661
49	4.5634	0.8040	0.4787	0.3364	1.1341	2.4068	0.4389	0.7179
50	4.6432	0.8478	0.5358	0.3385	0.9636	0.6775	0.3804	0.6606
66						0.5161		

Table 23: FIS best model configuration for number of people hijacked in each region

Region	MAE	Prediction performance	Cluster Number
Afghanistan	0.5051	93.230%	2
Central	0.3982	91.97%	6
Eastern	0.4412	92.667%	45
North Eastern	0.2356	96.268%	6
Western	0.5161	91.176%	66
South Eastern	0.6444	92.07%	7
South Western	0.5926	92.639%	5
North Western	0.36	93.484%	2

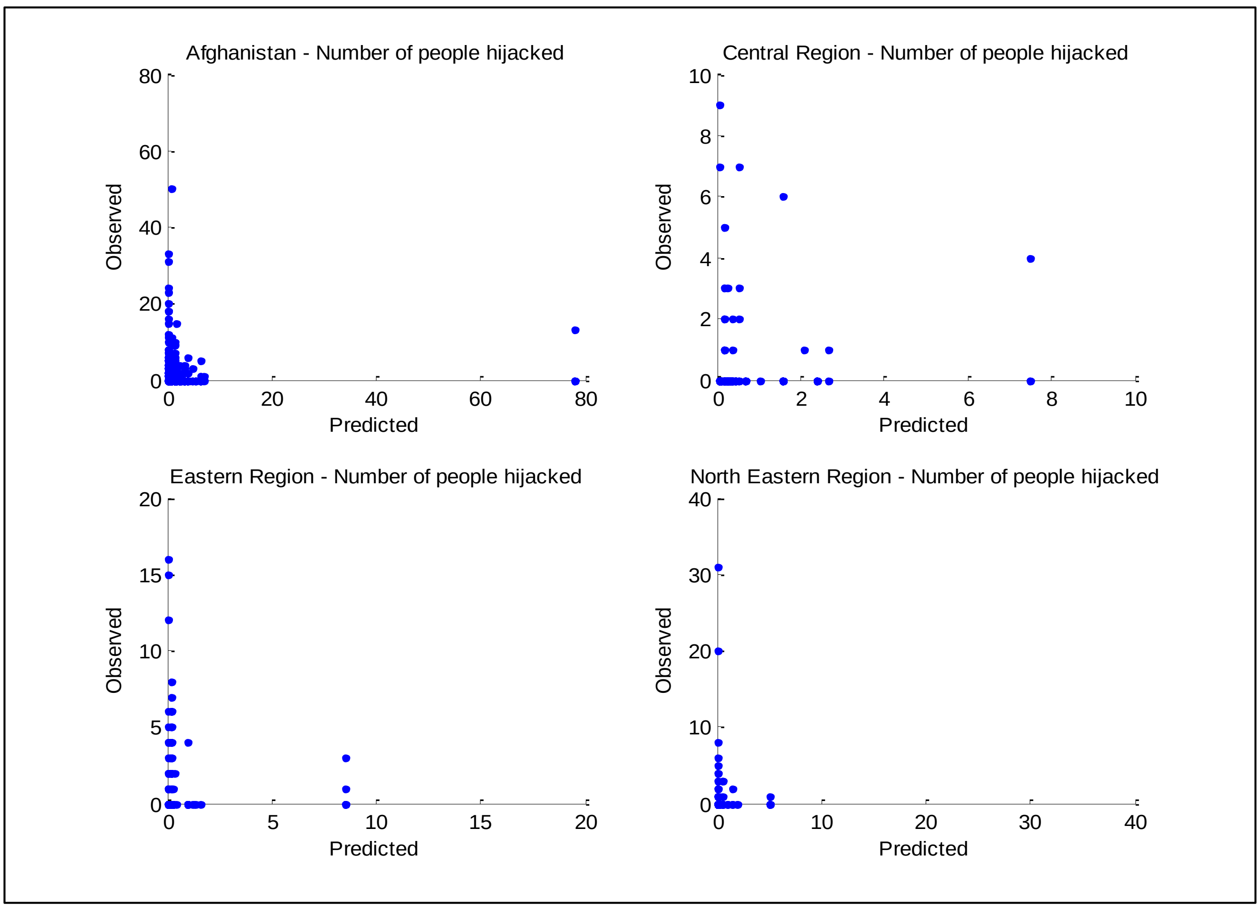


Figure 37: FIS predicted and observed values of number of people hijacked for Afghanistan, central, eastern, and north eastern regions

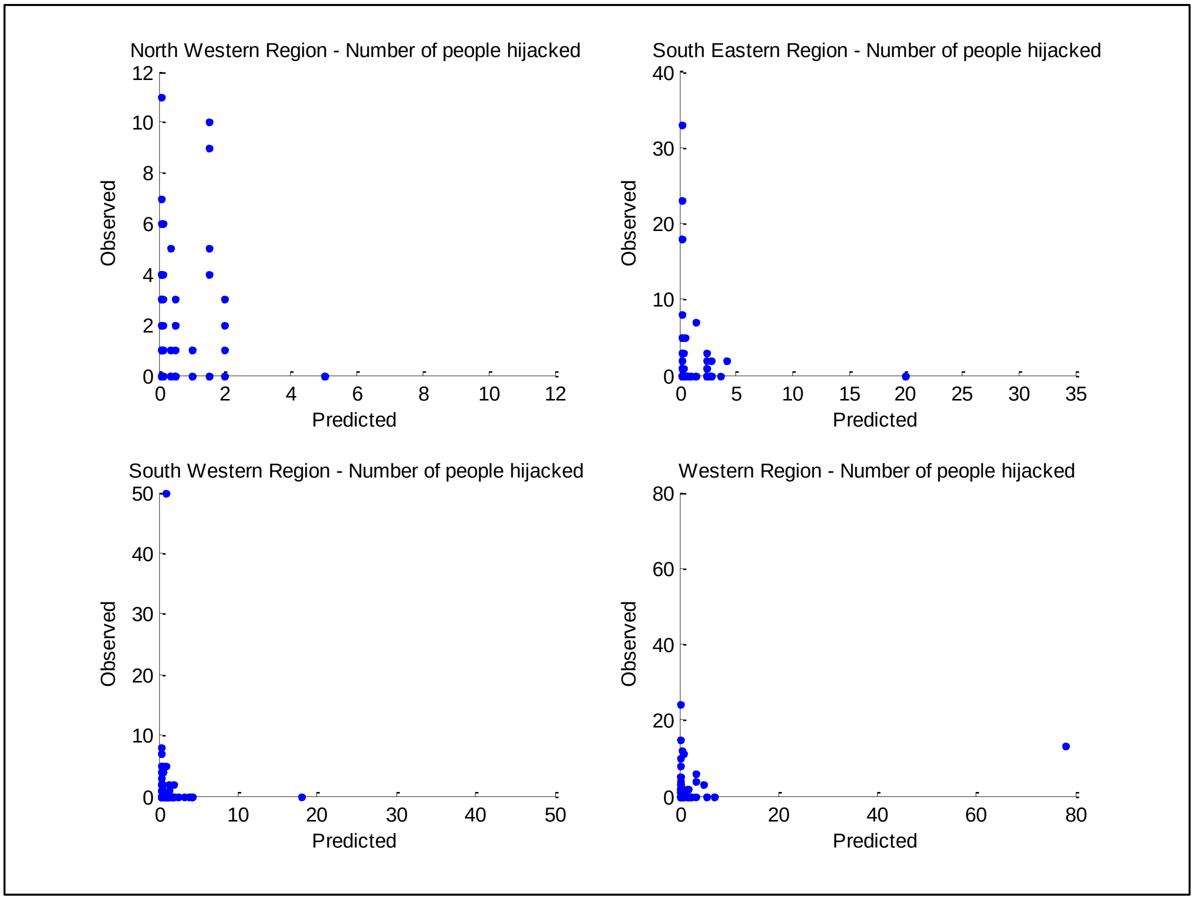


Figure 38: FIS predicted and observed values of number of people hijacked for north western, south eastern, south western, and western regions

4.2.4 Prediction of total number of adverse events

Experimental results of configurations for total number of adverse events and each region based on number of clusters were represented in Table 24. Based on Table 24, the minimum MAE values were highlighted and Table 25 provides information about the best FIS model configuration for total number of adverse events in each region. Based on the information in Table 25, the MAE values vary between 0 and 1 for all regions except for south eastern and south western regions. Corresponding percentage values of prediction performance vary around

85%. Central, eastern, north eastern, south eastern and north western regions had better prediction performance percentage value than Afghanistan. North eastern region had the best prediction performance accuracy among seven regions, the MAE value was found as 0.4827 and the percentage value of prediction performance was found as 89.17%. On the other side, south western region had the worst prediction performance accuracy, the MAE value was calculated as 1.294 and the percentage value of prediction performance was found as 77.08%

Figure 39 provides information about FIS predicted and observed values of total number of adverse events for Afghanistan and the regions of central, eastern, and north eastern and Figure 40 provides same information type for the regions of north western, south eastern, south western and western.

Table 24: Total number of adverse events – FIS best configuration for each region based on number of cluster

Cluster number	**Mean Absolute Error (MAE)**							
	Afgh.	**Central**	**Eastern**	**N.East.**	**S.East.**	**Western**	**N.W.**	**S.W.**
1	7.9129	5.0688	2.1317	3.1779	7.8495	2.5369	1.5185	5.7278
2	1.5578	1.1929	1.1810	0.6152	1.8266	1.2341	0.7611	2.1321
3	1.7695	1.1315	1.3073	0.5989	1.6530	1.3981	0.8137	2.5261
4	1.7757	1.1195	0.8138	0.5985	1.6591	1.3421	0.9044	2.4255
5	1.3314	1.1966	0.7937	0.5941	1.4402	1.0297	0.5388	1.7327
6	1.1163	0.9763	0.7793	0.6064	1.3892	1.0310	0.5374	1.7529
7	1.1466	0.9928	0.7797	0.5700	1.3752	1.0615	0.5362	1.7677
8	1.1115	1.0075	0.8117	0.6241	1.3752	1.0393	0.5426	1.6128
9	1.1078	1.0295	0.7898	0.6241	1.4773	1.0403	0.5577	1.6508
10	1.1052	1.0252	0.7890	0.6494	1.4597	1.0407	0.5553	1.6539
11	1.1183	1.0541	0.7876	0.5003	1.4759	1.0793	0.5855	1.6917
12	1.1187	1.0400	0.7874	0.6450	1.4472	1.0060	0.5671	1.6818
13	1.1315	1.0652	0.8243	0.5228	1.4334	1.1148	0.5769	1.7267
14	1.1241	1.0585	0.8212	0.5230	1.4175	1.0119	0.5882	1.7321
15	1.1178	1.0752	0.8058	0.5133	1.5689	1.0396	0.6233	1.7531
16	1.1673	1.0873	0.7914	0.5610	1.5425	1.0419	0.6021	1.7474
17	1.1545	1.0822	0.7951	0.5136	1.5975	1.0524	0.6038	1.7472

Cluster number	Mean Absolute Error (MAE)							
	Afgh.	**Central**	**Eastern**	**N.East.**	**S.East.**	**Western**	**N.W.**	**S.W.**
18	1.1665	1.0709	0.7964	0.5340	1.6553	1.0418	0.6215	1.7410
19	1.1512	1.0708	0.7821	0.5632	1.5316	1.0674	0.5749	1.7534
20	1.1421	1.0721	0.7805	0.5142	1.5566	1.0365	0.6333	1.7454
21	1.1112	1.0800	0.7750	0.5162	1.6609	1.0556	0.5820	1.7337
22	1.1053	1.0836	0.7685	0.5365	1.7588	1.0296	0.5785	1.7335
23	1.1476	1.0610	0.7813	0.5114	1.7508	1.0185	0.6081	1.7219
24	1.1303	1.0088	0.7643	0.5368	1.7533	1.0725	0.5895	1.6146
25	1.1387	1.0757	0.7420	0.4999	1.7959	1.0262	0.5893	1.7073
26	1.1137	1.0849	0.7634	0.4943	1.7700	1.0287	0.6057	1.7106
27	1.1219	1.0853	0.7729	0.4958	1.7860	1.0135	0.5861	1.5465
28	1.1288	1.0640	0.7736	0.6085	1.7810	1.0048	0.7881	1.5695
29	1.0919	1.0630	0.7680	0.5162	1.7619	1.0383	0.7951	1.5039
30	1.1423	1.0435	0.7672	0.4984	1.6660	1.0621	0.5758	1.4130
31	1.0113	1.0610	0.7587	0.6102	1.7872	0.9929	0.7865	1.3959
32	1.0576	1.0804	0.7589	0.4884	1.7369	1.0542	0.7791	1.4371
33	1.0544	1.0733	0.7702	0.6074	1.3723	1.0204	0.6724	1.4696
34	1.0609	1.0736	0.7605	0.4890	1.6417	1.0303	0.7491	1.3862
35	1.0521	1.0598	0.7671	0.6115	1.6640	0.9585	0.5899	1.3739
36	1.0485	1.0701	0.7345	0.4827	1.7907	1.0181	0.5777	1.4108
37	1.0542	1.0748	0.7891	0.6124	1.2653	1.0249	0.5722	1.3504
38	1.0858	1.0865	0.7608	0.6106	1.2899	1.0089	0.6771	1.3627
39	1.0692	1.0858	0.7333	0.6048	1.2314	0.9893	0.7607	1.4160
40	1.0698	1.0631	0.7687	0.6068	1.3178	1.0304	0.6689	1.5195
41	1.0582	1.0282	0.7646	0.6070	1.7013	1.0262	0.6788	1.3242
42	1.0383	1.0850	0.7264	0.5934	1.2769	1.0353	0.6654	1.3427
43	1.0565	1.0919	0.7384	0.6114	1.4497	1.0386	0.6883	1.4406
44	1.0553	1.0903	0.7364	0.6135	1.1971	0.9549	0.6721	1.4404
45	1.0337	1.0616	0.7349	0.6135	1.4328	0.9506	0.7532	1.4688
46	1.0507	1.0980	0.7169	0.7169	1.4971	1.0353	0.6746	1.3208
47	0.9957	1.0684	0.7478	0.5786	1.2479	0.9904	0.5793	1.4773
48	1.0677	0.9941	0.7648	0.6115	1.2612	1.0240	0.6842	1.4508
49	1.0238	1.0572	0.7247	0.6114	1.3341	0.9546	0.6759	1.4347
50	1.0094	1.0278	0.7600	0.5765	1.1922	1.1106	0.8804	1.3436
69					1.1770			
170	0.9352							
180								1.2946

Table 25: FIS best model configuration for total number of adverse events in each region

Region	MAE	Prediction performance	Cluster Number
Afghanistan	0.9352	79.64%	170
Central	0.9763	83.03%	6
Eastern	0.7168	86.333%	46
North Eastern	0.4827	89.179%	36
Western	0.9506	77.124%	45
South Eastern	1.1770	82.527%	69
South Western	1.2946	77.083%	180
North Western	0.5362	90.303%	7

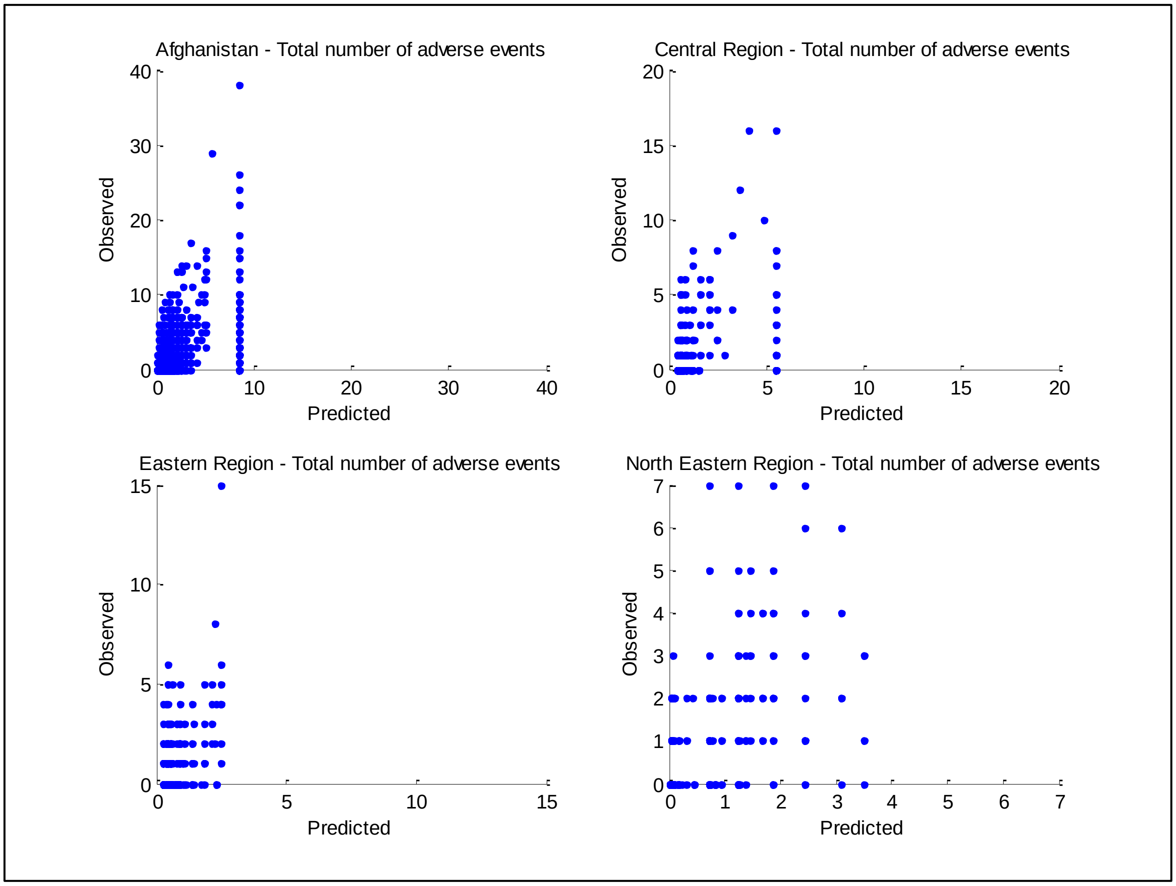


Figure 39: FIS predicted and observed values of total number of adverse events for Afghanistan, central, eastern, and north eastern region

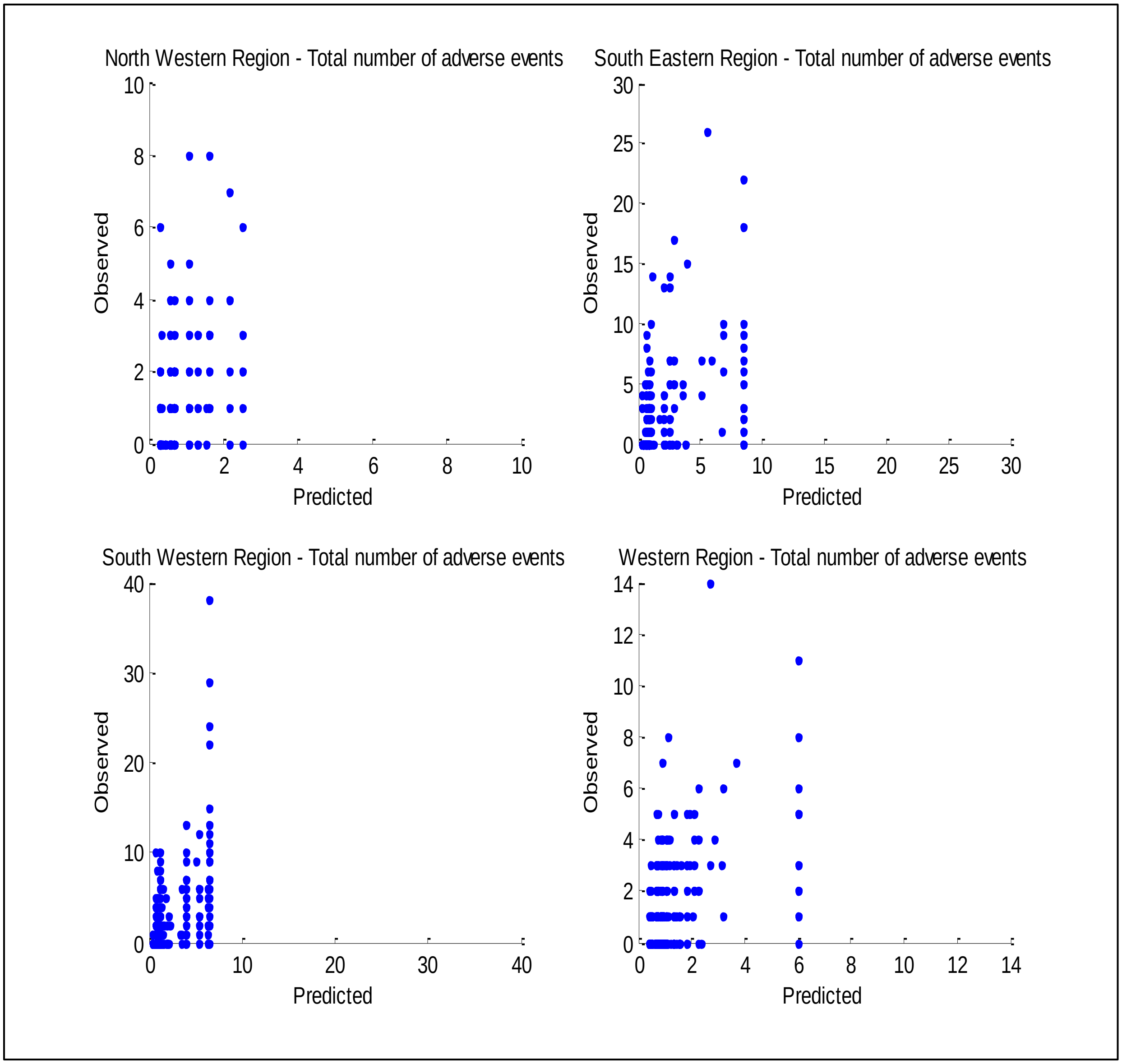


Figure 40: FIS predicted and observed values of total number of adverse events for north western, south eastern, south western, and western regions

4.3 ANFIS Model Development

First of all, we applied "exhsrch" (exhaustive search) function for input selection in ANFIS modeling using MATLAB environment. The input variables were coded from x1 to x89. The input name and corresponding codes are tabulated in Table 26. This function allows performing an exhaustive search on selecting 1 to 4 inputs from a large set of inputs. In this research, the most two effective inputs were selected from dataset of 89 inputs for each dependent variable and region (Table 27). The parameters of "exhsrch" function are explained as follows:

exhsrch(1, training data, testing data, input name); Where,

- *the first parameter 1* determines the number of input combinations to be tested in the search.
- *training data* represents the years between 2004 and 2009 and
- *testing data* represents the year 2010.
- *input name* represents the list of all inputs.

The left-most independent variable in Figure 41 has the minimum error, in other words it is the most relevant with respect to the dependent variable. It is indicated that the corresponding independent variables "number of people killed at month t-1" and "commerce and industry project aid number at year t-2" coded as "x89" and "x17" are the most influential.

Table 26: Input variable and corresponding code

Input variable	Code	Input variable	Code	Input variable	Code	Input variable	Code
B(t-2)Agriculture	x1	B(t-1)Agriculture	x29	B(t)Agriculture	x57	Urban male population density	x85
B(t-2)Capacity building	x2	B(t-1)Capacity building	x30	B(t)Capacity building	x58	Urban female population density	x86
B(t-2)Commerce and industry	x3	B(t-1)Commerce and industry	x31	B(t)Commerce and industry	x59	Rural male population density	x87
B(t-2)Community development	x4	B(t-1)Community development	x32	B(t)Community development	x60	Rural female population density	x88
B(t-2)Education	x5	B(t-1)Education	x33	B(t)Education	x61	Adverse event number at month t-1	x89
B(t-2)Emergency assistance	x6	B(t-1)Emergency assistance	x34	B(t)Emergency assistance	x62		
B(t-2)Energy	x7	B(t-1)Energy	x35	B(t)Energy	x63		
B(t-2)Environment	x8	B(t-1)Environment	x36	B(t)Environment	x64		
B(t-2)Gender	x9	B(t-1)Gender	x37	B(t)Gender	x65		
B(t-2)Governance	x10	B(t-1)Governance	x38	B(t)Governance	x66		
B(t-2)Health	x11	B(t-1)Health	x39	B(t)Health	x67		
B(t-2)Security	x12	B(t-1)Security	x40	B(t)Security	x68		
B(t-2)Transport	x13	B(t-1)Transport	x41	B(t)Transport	x69		
B(t-2)Water and sanitation	x14	B(t-1)Water and sanitation	x42	B(t)Water and sanitation	x70		
A(t-2)Agriculture	x15	A(t-1)Agriculture	x43	A(t)Agriculture	x71		
A(t-2)Capacity building	x16	A(t-1)Capacity building	x44	A(t)Capacity building	x72		
A(t-2)Commerce and industry	x17	A(t-1)Commerce and industry	x45	A(t)Commerce and industry	x73		
A(t-2)Community development	x18	A(t-1)Community development	x46	A(t)Community development	x74		
A(t-2)Education	x19	A(t-1)Education	x47	A(t)Education	x75		
A(t-2)Emergency assistance	x20	A(t-1)Emergency assistance	x48	A(t)Emergency assistance	x76		
A(t-2)Energy	x21	A(t-1)Energy	x49	A(t)Energy	x77		
A(t-2)Environment	x22	A(t-1)Environment	x50	A(t)Environment	x78		
A(t-2)Gender	x23	A(t-1)Gender	x51	A(t)Gender	x79		
A(t-2)Governance	x24	A(t-1)Governance	x52	A(t)Governance	x80		
A(t-2)Health	x25	A(t-1)Health	x53	A(t)Health	x81		
A(t-2)Security	x26	A(t-1)Security	x54	A(t)Security	x82		
A(t-2)Transport	x27	A(t-1)Transport	x55	A(t)Transport	x83		
A(t-2)Water and sanitation	x28	A(t-1)Water and sanitation	x56	A(t)Water and sanitation	x84		

B(t-2): Budget at year t-2
B(t-1): Budget at year t-1
B(t): Budget at year t

A(t-2): Aid Number at year t-2
A(t-1): Aid number at year t-1
A(t): Aid Number at year t

After selecting the most two effective inputs, the final models were generated using ANFIS structure. Eight different types of membership functions were considered in this research: Triangular-shaped membership function, Trapezoidal-shaped membership function, Generalized bell-shaped membership function, Gaussian curve membership function, Gaussian combination membership function, Π-shaped membership function, Difference between two sigmoid functions membership function, and Product of two sigmoidal membership functions.

Table 27: Selected two inputs for each dependent variable and region

Region	Number of people killed	Number of people wounded	Number of people hijacked	Number of total adverse events
Central	x17, x86	x86, x85	x19, x45	x89, x85
Eastern	x16, x18	x4, x44	x75, x66	x89, x18
North Eastern	x85, x86	x85, x86	x16, x89	x89, x4
Western	x89, x17	x89, x85	x44, x37	x89, x85
South Eastern	x89, x75	x89,75	x89, x21	x89, x75
North Western	x89, x18	x17, x85	x89, x23	x89, x85
South Western	x89, x73	x86, x85	x42, x54	x89, x86
Afghanistan	x89, x17	x89, x86	x89, x18	x89, x75

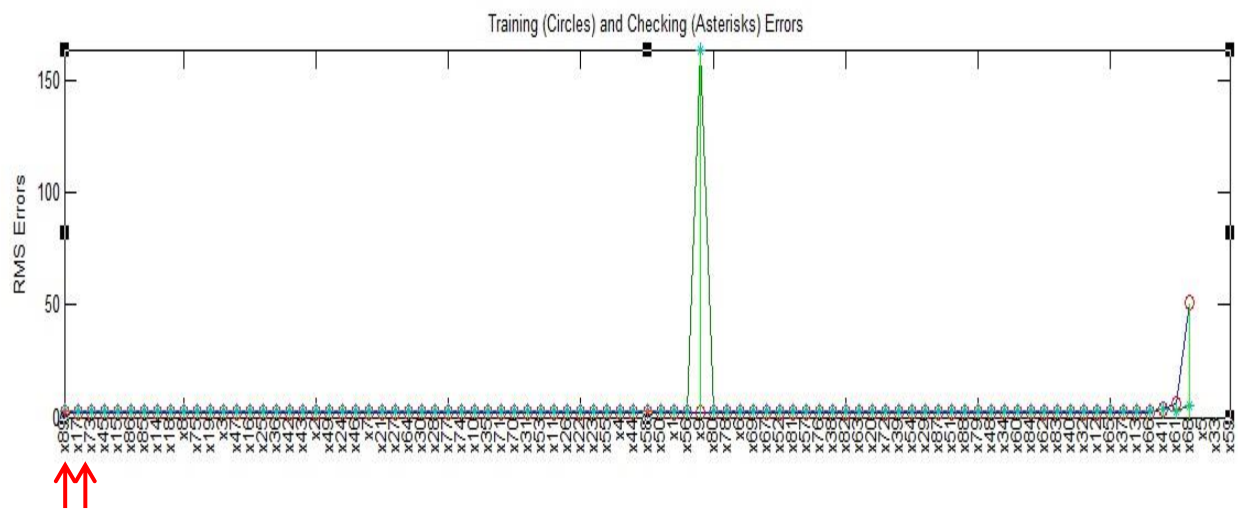


Figure 41: Illustration of every input variable's influence on number of people killed in Afghanistan

All these membership functions were represented graphically in Section 3.1.2.1. For all models, each membership function type was tested individually and compared to each other. ANFIS experimental results of all configurations based on dependent variables and regions were represented in following sections. The best configuration was selected according to the MAE values.

4.3.1 Prediction of number of people killed

Experimental results of configurations for number of people killed in each region based on membership function type and its number were represented in Table 28. Based on Table 28, the minimum MAE values were highlighted and Table 29 provides information about the best ANFIS model configuration for number of people killed in each region. Based on the information in Table 29, the MAE values vary between 0 and 1 for all regions except for south western region. Corresponding percentage values of prediction performance vary around 90%.

Central, eastern, north eastern, western and north western regions had better prediction performance percentage value than Afghanistan. North western region had the best prediction performance accuracy among seven regions, the MAE value was found as 0.2449 and the percentage value of prediction performance was found as 95.75%. On the other side, south western region had the worst prediction performance accuracy, the MAE value was calculated as 1.91 and the percentage value of prediction performance was found as 68.61%

Figure 42 provides information about ANFIS predicted and observed values of number of people killed for Afghanistan and the regions of central, eastern, and north eastern and Figure 43 provides same information type for the regions of north western, south eastern, south western and western.

Table 28: Number of people killed– ANFIS best configuration for each region based on membership function type and its number

M.F. Type	**# of M.F.**	**Mean Absolute Error (MAE)**							
		Afgh.	**Central**	**Eastern**	**N.E**	**S.E**	**West.**	**N.W**	**S.W**
dsigmf	2	0.748	0.5601	0.3758	0.4135	0.9505	0.8176	0.2576	1.9167
	3	0.823	0.5528	0.4432	0.4139	1.0197	0.8323	1.9588	1.9592
	4	0.785	0.5598	0.4266	0.4133	0.9843	1.8985	2.0688	1.9262
	5	1.291	0.5720	0.4627	0.4133	1.0636	15.383	0.2749	2.3983

M.F. Type	# of M.F.	Mean Absolute Error (MAE)							
		Afgh.	Central	Eastern	N.E	S.E	West.	N.W	S.W
	6	1.886	0.6221	0.5514	0.4142	1.1615	5.1312	0.8139	1.9591
gauss2mf	2	0.744	0.5217	0.3761	0.4130	0.9358	0.7154	0.2591	2.0185
	3	0.736	0.5551	0.3956	0.4132	0.9906	0.8835	0.8951	1.9535
	4	1.020	0.5636	0.4145	0.4145	0.9693	1.6894	11.348	2.1588
	5	1.736	0.5645	0.4185	0.4142	1.0607	20.173	0.2753	2.6452
	6	1.976	0.6226	0.5537	0.4142	1.1234	3.1224	0.2883	1.9206
gaussmf	2	0.742	0.5405	0.3761	0.4135	0.9346	0.6722	0.2660	2.1295
	3	0.750	0.5886	0.4164	0.4132	0.9648	0.8920	0.5499	1.9854
	4	0.846	0.5698	0.4159	0.4153	1.0359	2.0288	4.5876	2.1648
	5	1.038	0.5707	0.4422	0.4145	1.0533	22.444	0.4720	1.9284
	6	1.480	0.6274	0.4413	0.4144	1.1048	8.1013	0.2999	2.4117
gbellmf	2	0.745	0.54	0.3763	0.4134	0.9395	0.6728	0.2742	2.1196
	3	0.740	0.5803	0.3850	0.4140	0.9757	1.0291	0.2816	1.9303
	4	0.827	0.5667	0.4323	0.4145	1.0181	9.1691	2.4877	2.0404
	5	1.200	0.5721	0.4758	0.4143	1.0493	6.0165	0.9719	2.3243
	6	2.187	0.6028	0.5941	0.4143	1.1536	20.636	0.3428	1.9920
pimf	2	0.742	0.5087	0.3749	0.4139	0.9453	0.9459	0.2449	1.9296
	3	0.742	0.5443	0.3817	0.4136	0.9568	0.7815	0.2474	1.9871
	4	0.745	0.5594	0.3983	0.4149	0.9912	0.7285	0.2623	1.9377
	5	0.799	0.5619	0.4237	0.4148	0.9841	0.8855	0.2621	1.9616
	6	5.594	0.6172	0.4932	0.4147	1.1763	1.1002	0.2807	1.9995
psigmf	2	0.748	0.5603	0.3758	0.4135	0.9505	0.8176	0.2576	1.9165
	3	0.815	0.5549	0.4434	0.4159	1.0126	0.8323	1.9593	1.9576
	4	0.785	0.5654	0.4266	0.4153	0.9833	1.8991	2.0720	1.9212
	5	1.755	0.5719	0.4628	0.4153	1.0635	15.384	0.2750	2.3983
	6	1.896	0.6057	0.5514	0.4152	1.1676	5.1317	0.8139	1.9593
trapmf	2	0.742	0.5136	0.3745	0.4139	0.9398	0.9536	0.2457	1.9401
	3	0.736	0.5507	0.3864	0.4136	0.9583	0.7084	0.2482	1.9254
	4	0.741	0.5605	0.3937	0.4139	0.9903	0.7152	0.2544	1.9308
	5	0.818	0.5627	0.4214	0.4138	0.9910	0.8716	0.2653	1.9691
	6	0.993	0.5981	0.4315	0.4137	1.0879	1.2359	0.4196	1.9803
trimf	2	0.759	7.0582	0.3845	0.4136	0.9604	0.8435	0.2487	1.9979
	3	0.748	4.1897	0.3922	0.4136	1.0320	0.7846	0.2788	2.2704
	4	0.762	1.8485	0.4107	0.4131	1.0068	1.3943	0.9718	1.9467
	5	1.177	4.2074	0.4186	0.4133	1.1155	2.9321	3.3913	2.3093
	6	1.277	5.1091	0.4398	0.4133	1.0503	2.3751	0.2817	2.3942

Table 29: ANFIS best model configuration for number of people killed in each region

Region	MAE	Prediction performance	Membership function	Number of membership function
Afghanistan	0.7361	86.645%	gauss2mf	3
Central	0.5087	92.878%	pimf	2
Eastern	0.3745	93.333%	trapmf	2
North Eastern	0.4130	93.283%	gauss2mf	2
Western	0.6722	86.928%	gaussmf	2
South Eastern	0.9346	84.006%	gaussmf	2
South Western	1.9165	68.611%	psigmf	2
North Western	0.2449	95.757%	pimf	2

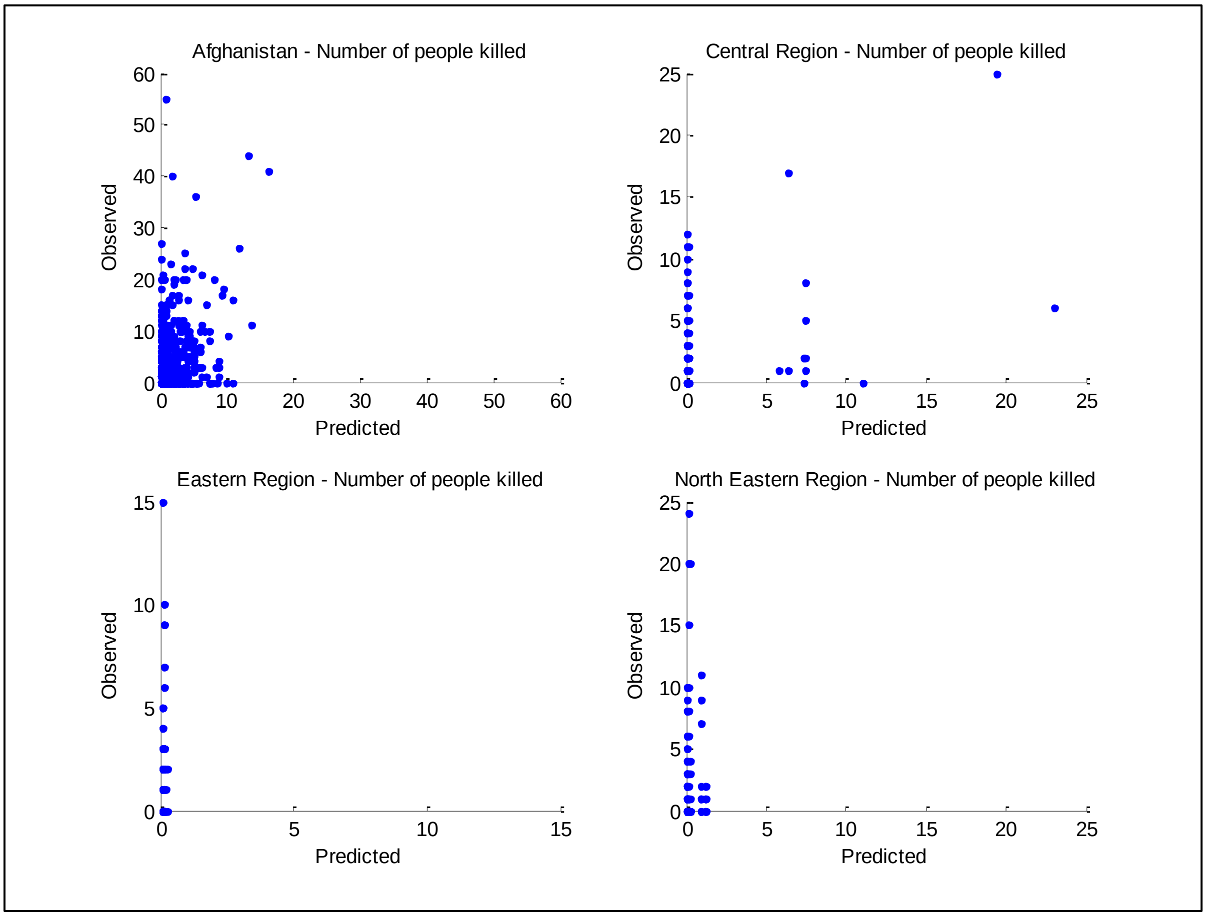


Figure 42: ANFIS predicted and observed values of number of people killed for Afghanistan, central, eastern, and north eastern regions

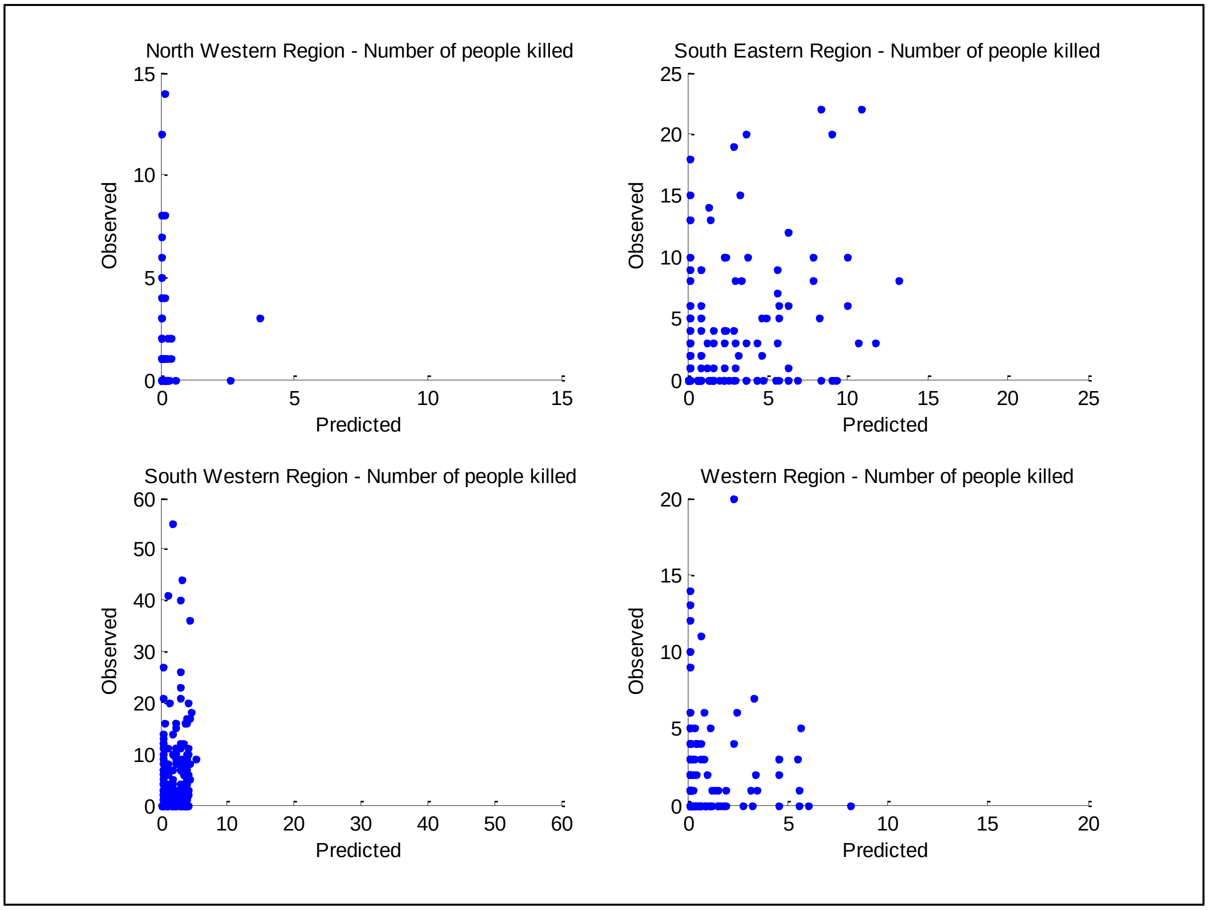


Figure 43: ANFIS predicted and observed values of number of people killed for north western, south eastern, south western, and western regions

4.3.2 Prediction of number of people wounded

Experimental results of configurations for number of people wounded in each region based on membership function type and its number were represented in Table 30. Based on Table 30, the minimum MAE values were highlighted and Table 31 provides information about the best ANFIS model configuration for number of people wounded in each region. Based on the information in Table 31, the MAE values vary between 0 and 1 for all regions except for entire country, central, south eastern and south western regions. Corresponding percentage values of prediction performance vary around 90%.

All regions except south western region had better prediction performance percentage value than Afghanistan. North western region had the best prediction performance accuracy among seven regions, the MAE value was found as 0.4295 and the percentage value of prediction performance was found as 94.54%. On the other side, south western region had the worst prediction performance accuracy, the MAE value was calculated as 2.44 and the percentage value of prediction performance was found as 75.55%

Figure 44 provides information about ANFIS predicted and observed values of number of people wounded for Afghanistan and the regions of central, eastern, and north eastern and Figure 45 provides same information type for the regions of north western, south eastern, south western and western.

Table 30: Number of people wounded– ANFIS best configuration for each region based on membership function type and its number

M.F. Type	**# of M.F.**	**Mean Absolute Error (MAE)**							
		Afgh.	**Central**	**Eastern**	**N.E**	**S.E**	**West.**	**N.W**	**S.W**
dsigmf	2	1.239	1.1034	1.261	0.6337	1.4581	0.6496	0.4361	2.4682
	3	1.248	1.1030	1.526	0.6339	4.0937	0.7921	0.4379	2.4690
	4	1.244	1.1034	129.52	0.6360	38.862	0.8655	0.4402	2.4677
	5	1.347	1.1039	129.52	0.6364	3.0854	1.8351	0.4567	2.4659
	6	1.364	1.1039	129.52	0.6363	3.4355	1.4891	0.4721	2.4655
gauss2mf	2	1.235	1.1045	1.40	0.6356	1.4201	0.6475	0.4328	2.4543
	3	1.224	1.1384	1.38	0.6353	1.7434	0.8490	0.4374	2.4483
	4	1.313	1.1378	124.91	0.6367	43.227	0.8068	0.4392	2.4684
	5	1.411	1.1379	129.53	0.6362	3.5785	1.9393	0.6024	2.4685
	6	1.442	1.1388	129.53	0.6362	5.3611	2.8313	0.4800	2.4678
gaussmf	2	1.234	1.1053	1.46	0.6359	1.374	0.6463	0.4334	2.4667

M.F. Type	# of M.F.	Mean Absolute Error (MAE)							
		Afgh.	**Central**	**Eastern**	**N.E**	**S.E**	**West.**	**N.W**	**S.W**
	3	1.221	1.1025	1.42	0.6369	2.264	0.8453	0.4420	2.4691
	4	1.708	1.1329	3.28	0.6389	10.946	0.8320	0.4417	2.4684
	5	1.253	1.1329	129.53	0.6363	21.347	1.0442	0.4455	2.4675
	6	1.433	1.1331	129.53	0.6361	7.782	1.0068	0.4869	2.4662
gbellmf	2	1.233	1.1041	1.44	0.6388	1.402	0.6453	0.4318	2.4667
	3	1.223	1.1013	1.36	0.6387	4.502	0.8496	0.4406	2.4690
	4	1.320	1.1143	1.37	0.6365	17.638	0.7117	0.4421	2.4688
	5	1.387	1.1578	129.6	0.6361	116.91	0.8693	0.4473	2.4672
	6	1.503	1.1248	129.53	0.6362	183.43	1.0173	0.4725	2.4658
pimf	2	1.226	1.1441	1.38	0.6391	1.4350	0.6481	0.4295	2.5660
	3	1.219	1.1441	1.28	0.6318	1.3408	0.6877	0.4368	2.5660
	4	1.251	1.1441	1.65	0.6388	6.4534	0.6832	0.4382	2.5660
	5	1.221	1.1441	468.96	0.6369	1.3700	0.7007	0.4742	2.5017
	6	1.218	1.1441	128.01	0.6369	1.4113	3.1044	0.4669	2.4686
psigmf	2	1.239	1.1012	1.260	0.6376	1.4568	0.6496	0.4361	2.4684
	3	1.229	1.1121	1.336	0.6369	4.1787	0.7911	0.4376	2.4690
	4	1.277	1.1121	0.975	0.6360	37.542	0.8652	0.4401	2.4678
	5	1.315	1.1122	0.975	0.6364	2.5462	1.8352	0.4586	2.4659
	6	1.367	1.1116	0.975	0.6363	3.5168	1.4883	0.4746	2.4655
trapmf	2	1.224	1.1441	1.42	0.6361	1.4167	0.6465	0.4299	2.5660
	3	1.237	1.1441	1.26	0.6368	1.3512	0.6984	0.4380	2.5660
	4	1.242	1.1441	1.50	0.6388	3.0381	0.7009	0.4379	2.5660
	5	1.242	1.1441	128.01	0.6369	1.3810	0.7035	0.4570	2.5017
	6	1.256	1.1441	128.01	0.6369	1.3488	1.1675	0.4728	2.4686
trimf	2	1.216	1.1036	1.35	0.6372	1.4475	0.6442	0.4345	2.4504
	3	1.220	1.1381	128.01	0.6372	1.3807	0.8074	0.4350	2.4556
	4	1.222	1.1377	128.01	0.6381	2.8379	0.8605	0.4493	2.4567
	5	1.230	1.1378	128.01	0.6380	3.3335	1.0385	0.4949	2.4564
	6	1.228	1.1372	128.01	0.6380	1.8072	0.9106	0.4524	2.4557

Table 31: ANFIS best model configuration for number of people wounded in each region

Region	MAE	Prediction performance	Membership function	Number of membership function
Afghanistan	1.2161	82.395%	trimf	2
Central	1.1012	90.151%	psigmf	2
Eastern	0.9750	87.331%	psigmf	4
North Eastern	0.6318	92.288%	pimf	3
Western	0.6442	85.784%	trimf	2
South Eastern	1.3408	82.795%	pimf	3
South Western	2.4483	75.555%	gaussmf	3
North Western	0.4295	94.541%	pimf	2

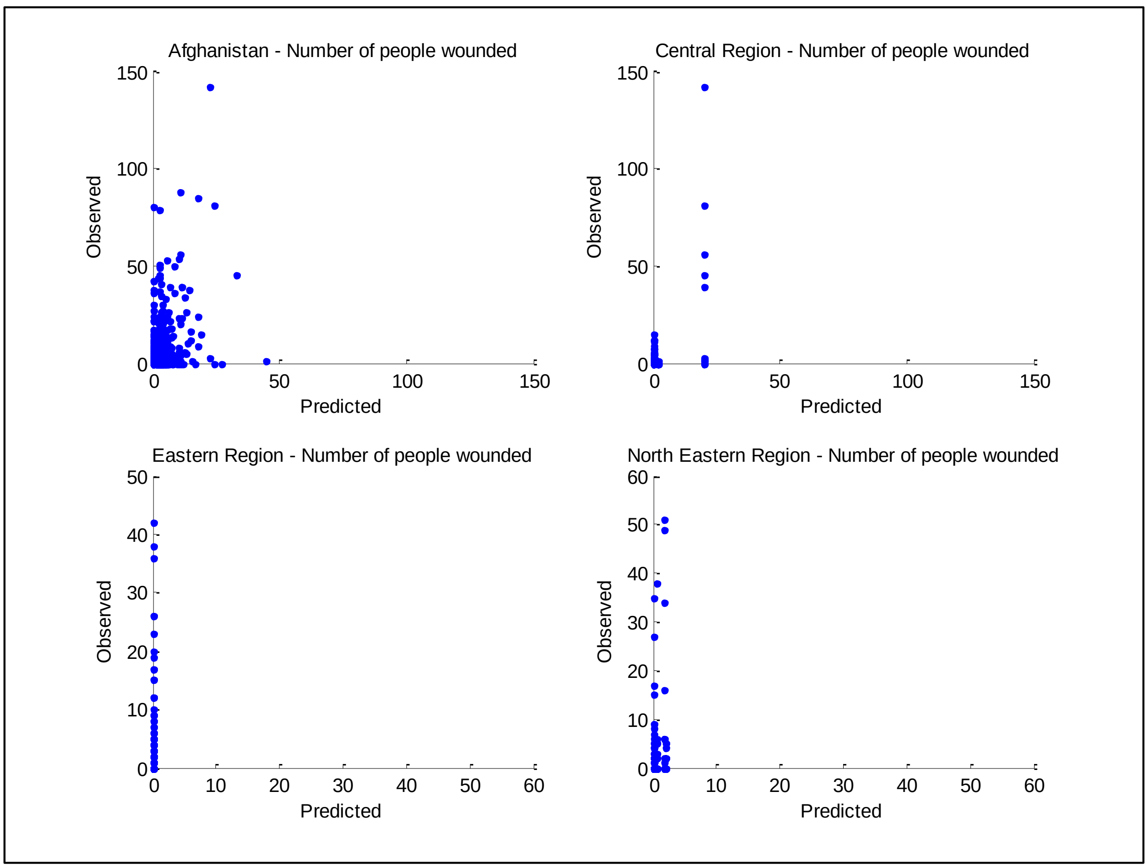


Figure 44: ANFIS predicted and observed values of number of people wounded for Afghanistan, central, eastern, and north eastern regions

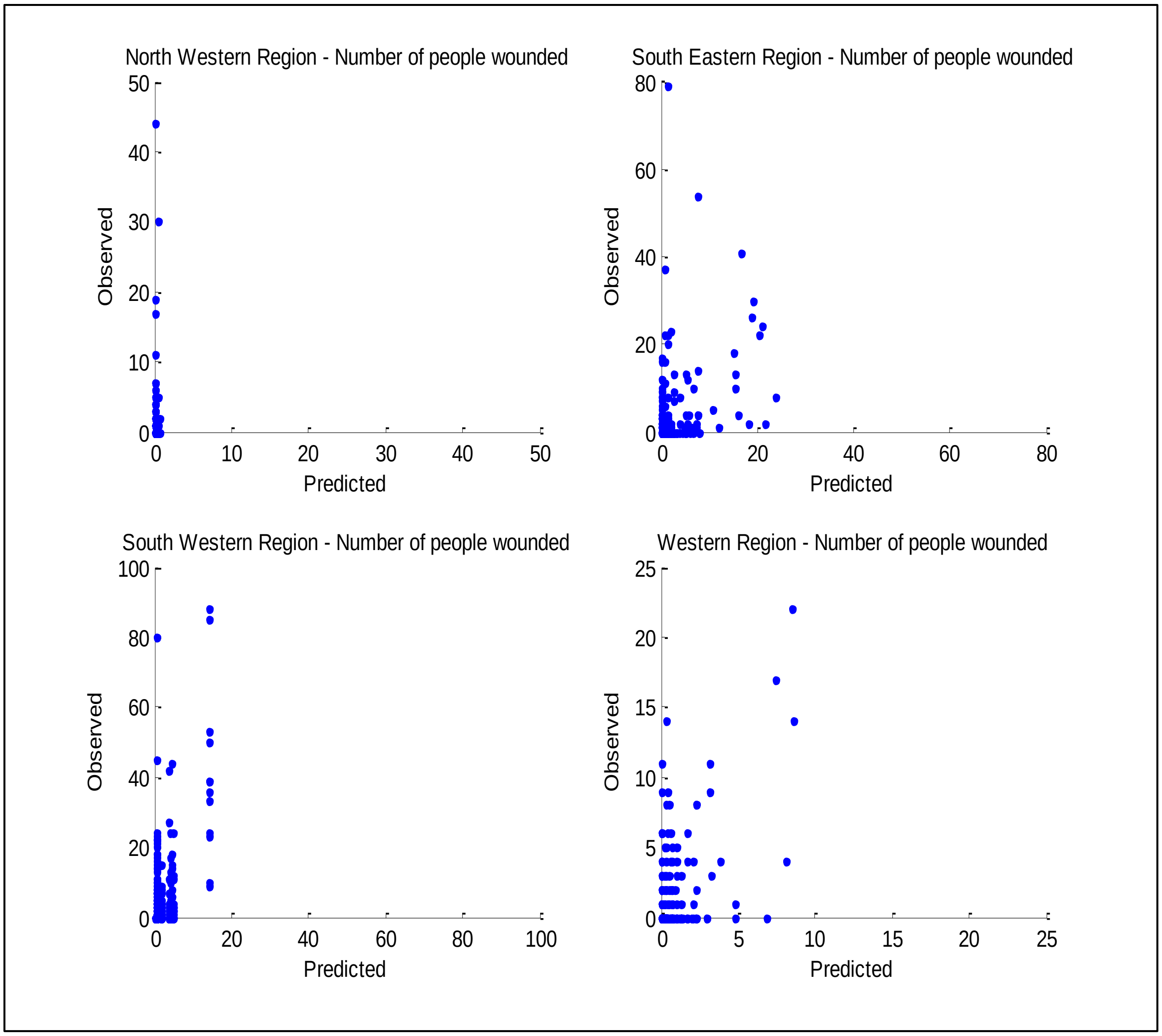


Figure 45: ANFIS predicted and observed values of number of people wounded for north western, south eastern, south western, and western regions

4.3.3 Prediction of number of people hijacked

Experimental results of configurations for number of people hijacked in each region based on membership function type and its number were represented in Table 32. Based on Table 32, the minimum MAE values were highlighted and Table 33 provides information about the best ANFIS model configuration for number of people hijacked in each region. Based on the information in Table 33, the MAE values vary between 0 and 0.4 for all regions and Afghanistan. Corresponding percentage values of prediction performance vary around 95%.

North eastern and south western regions had better prediction performance percentage value than Afghanistan. North eastern region had the best prediction performance accuracy among seven regions, the MAE value was found as 0.1563 and the percentage value of prediction performance was found as 97.38%. On the other side, south eastern region had the worst prediction performance accuracy, the MAE value was calculated as 0.33 and the percentage value of prediction performance was found as 93.28%

Figure 46 provides information about ANFIS predicted and observed values of number of people hijacked for Afghanistan and the regions of central, eastern, and north eastern and Figure 47 provides same information type for the regions of north western, south eastern, south western and western.

Table 32: Number of people hijacked– ANFIS best configuration for each region based on membership function type and its number

M.F. Type	**# of M.F.**	**Mean Absolute Error (MAE)**							
		Afgh.	**Central**	**Eastern**	**N.E**	**S.E**	**West.**	**N.W**	**S.W**
dsigmf	2	0.2375	0.1731	0.36	0.1583	0.3554	0.3610	0.4923	0.2333
	3	0.2406	0.1803	0.36	0.1611	1.1700	0.3619	0.2168	0.2327
	4	0.6073	0.1718	0.37	0.1566	10.996	0.3654	0.2166	247.47
	5	0.8316	0.1775	177.5	0.1575	0.9769	0.3708	0.2166	17.931
	6	0.3889	0.1697	8.27	0.1585	0.7761	0.3760	0.2166	17.931
gauss2mf	2	0.2393	0.1782	0.37	0.1567	0.3541	0.3617	0.6301	0.2328
	3	0.2396	0.1789	0.36	0.1574	1.2028	0.3637	0.2172	0.2327
	4	0.2391	0.1693	141.2	0.1579	14.521	0.3647	0.2166	247.47
	5	0.3059	0.1739	122.3	0.1585	0.7457	0.3694	0.2166	17.931
	6	0.3189	0.1698	8.27	0.1583	0.8846	0.3743	0.2166	17.931
gaussmf	2	0.2361	0.1804	0.365	0.1854	0.3375	0.3638	0.2452	0.2297
	3	0.2381	0.1709	0.368	0.1702	0.3630	0.3736	0.2169	0.2311
	4	0.2530	0.1745	0.367	0.1825	1.6145	0.3869	0.2166	247.47
	5	0.2903	0.1556	0.374	0.1596	6.3095	0.3878	0.2166	17.931

M.F. Type	# of M.F.	Mean Absolute Error (MAE)							
		Afgh.	Central	Eastern	N.E	S.E	West.	N.W	S.W
	6	0.3038	0.1701	5.137	0.1563	0.5264	0.3794	0.2166	17.931
gbellmf	2	0.2362	0.1790	0.365	0.1800	0.3694	0.3633	0.2257	0.2308
	3	0.2377	0.1727	0.366	0.1650	0.5820	0.3713	0.2169	0.2321
	4	0.2552	0.1698	0.366	0.1824	1.7076	0.3794	0.2167	247.47
	5	0.3571	0.1759	0.370	0.1594	2.0820	0.3788	0.2166	17.931
	6	0.9991	0.1793	0.478	0.1622	4.7516	0.3715	0.2166	17.931
pimf	2	0.2355	0.1780	0.364	0.1576	0.3557	0.3601	0.2162	0.2328
	3	0.2522	0.1751	0.363	0.1600	1.0148	0.3661	0.2167	0.2332
	4	0.2375	0.1734	0.369	0.1626	0.3445	0.3659	0.2166	0.2334
	5	0.2374	0.1788	0.718	0.3899	0.3375	0.3647	0.2166	0.2341
	6	0.2386	0.1770	0.383	0.1648	1.3042	0.3696	0.2166	0.2329
psigmf	2	0.2375	0.1731	0.368	0.1583	0.3554	0.3613	0.4923	0.2333
	3	0.2406	0.1803	0.364	0.1599	1.1589	0.3654	0.2168	0.2338
	4	0.6069	0.1705	0.368	0.1596	11.000	0.3656	0.2166	0.2344
	5	0.8316	0.1775	134.2	0.1673	0.9773	0.3708	0.2166	0.2369
	6	0.3872	0.1724	0.287	0.1693	0.7761	0.3765	0.2166	0.2369
trapmf	2	0.2354	0.1747	0.364	0.1572	0.3476	0.3601	0.2166	0.2320
	3	0.2395	0.1802	0.364	0.1636	0.4554	0.3658	0.2166	0.2332
	4	0.2356	0.1713	0.371	0.1613	0.3479	0.3651	0.2166	0.2334
	5	0.2391	0.1735	0.437	0.2934	0.7069	0.3652	0.2166	0.2343
	6	0.2395	0.1728	0.387	0.1598	0.6599	0.3740	0.2166	0.2318
trimf	2	0.2453	0.2342	0.365	0.1594	0.3295	0.3199	0.2204	0.2315
	3	0.2389	0.1724	0.371	0.1804	0.4339	0.4012	0.2166	0.2308
	4	0.2395	0.1775	2.983	0.1673	0.6647	0.3993	0.2168	0.2307
	5	0.2511	0.1796	4.218	0.1616	0.3709	0.4164	0.2166	0.2309
	6	0.24	0.1700	4.218	0.1605	0.3893	0.4135	0.2166	0.4486

Table 33: ANFIS best model configuration for number of people hijacked in each region

Region	MAE	Prediction performance	Membership function	Number of membership function
Afghanistan	0.2354	96.312%	trapmf	2
Central	0.1693	95.151%	gauss2mf	4
Eastern	0.2867	94.166%	psigmf	6
North Eastern	0.1563	97.388%	gaussmf	6
Western	0.3199	94.444%	trimf	2
South Eastern	0.3295	93.279%	trimf	2
South Western	0.2297	97.777%	gaussmf	2
North Western	0.2162	95.757%	pimf	2

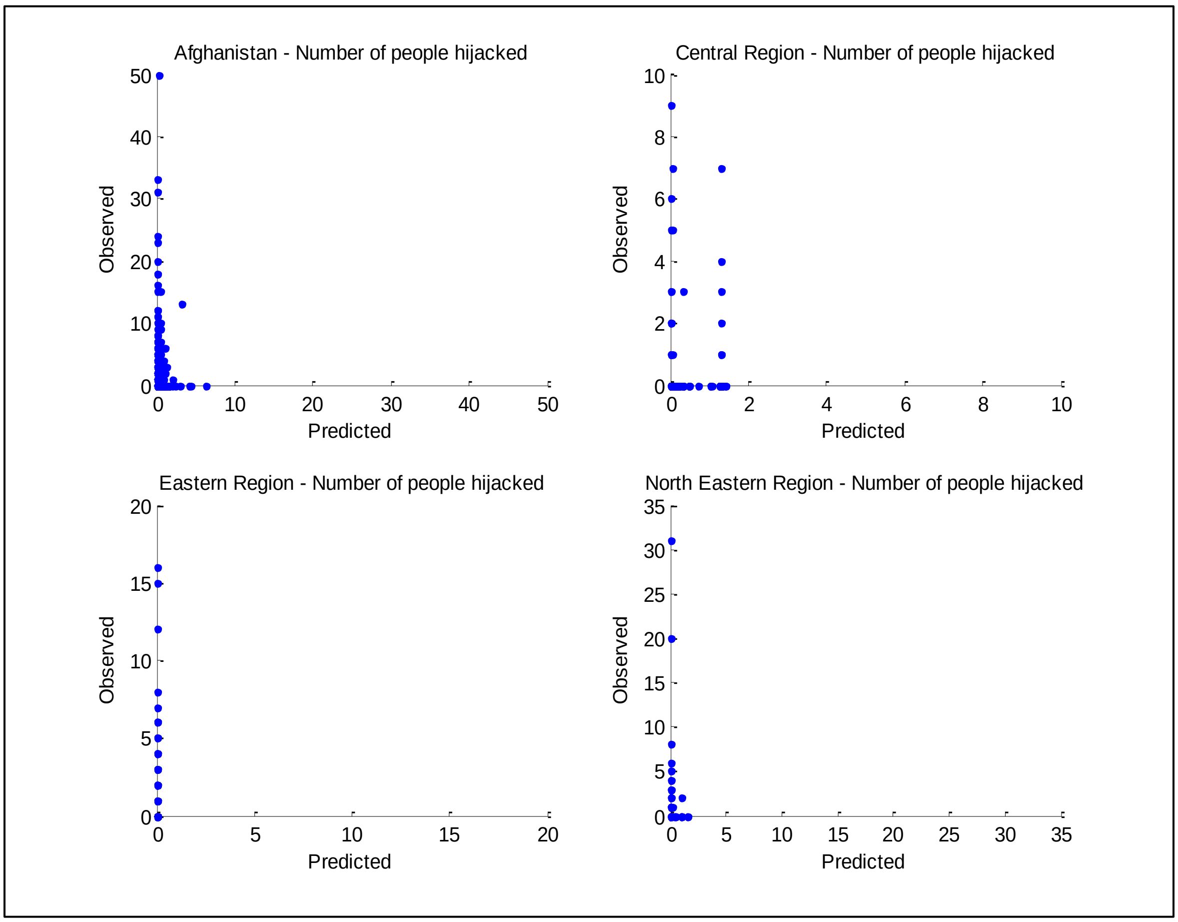


Figure 46: ANFIS predicted and observed values of number of people hijacked for Afghanistan and central, eastern, and north eastern regions

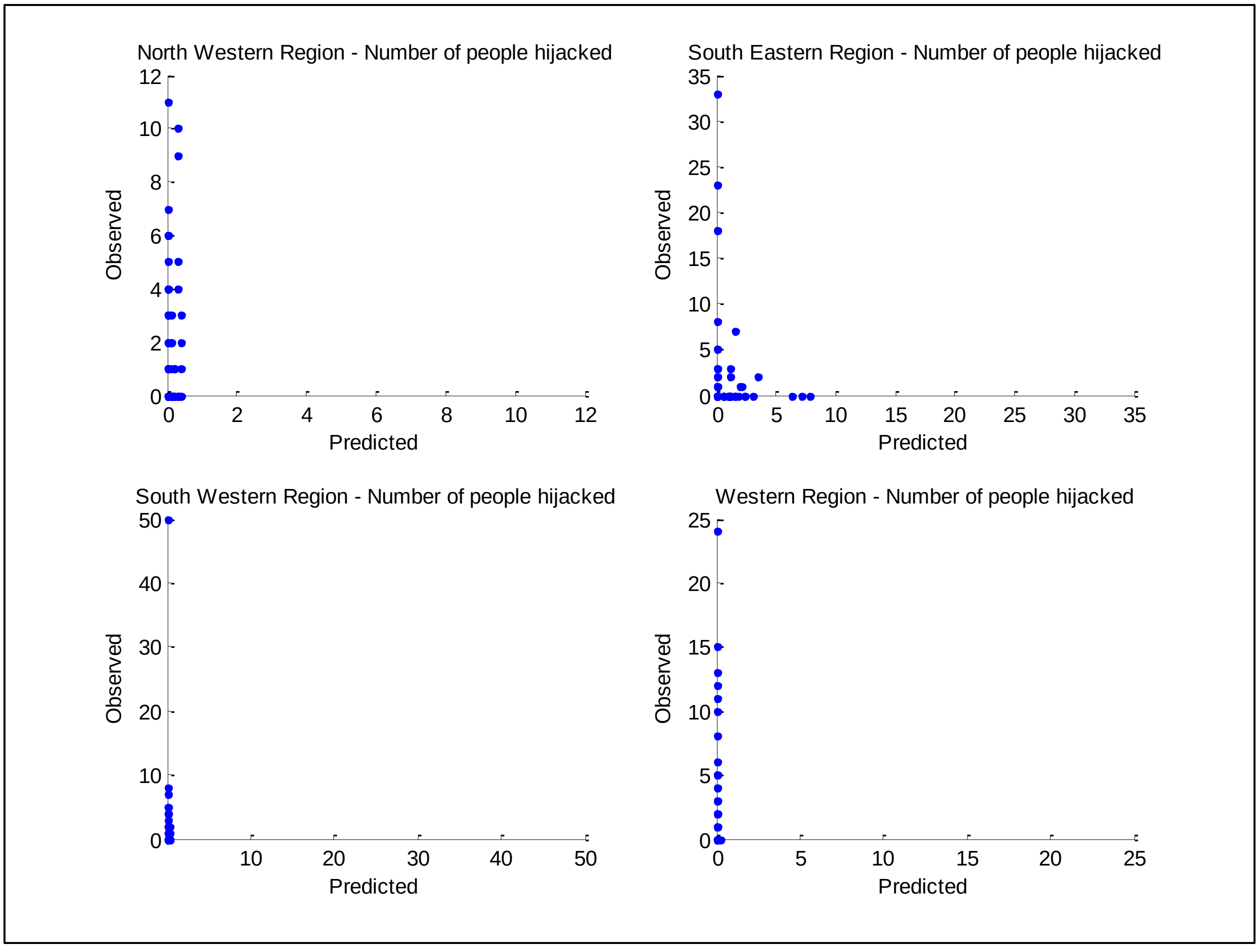


Figure 47: ANFIS predicted and observed values of number of people hijacked for north western, south eastern, south western, and western regions

4.3.4 Prediction of total number of adverse events

Experimental results of configurations for total number of adverse events in each region based on membership function type and its number were represented in Table 34. Based on Table 34, the minimum MAE values were highlighted and Table 35 provides information about the best ANFIS model configuration for total number of adverse events variable in each region.

Based on the information in Table 35, the MAE values vary between 0 and 1 for all regions and entire country. Corresponding percentage values of prediction performance vary around 90%.

Central, eastern, north eastern and north western regions had better prediction performance percentage value than Afghanistan. North eastern region had the best prediction performance accuracy among seven regions, the MAE value was found as 0.3725 and the percentage value of prediction performance was found as 89.67%. On the other side, south western region had the worst prediction performance accuracy, the MAE value was calculated as 0.935 and the percentage value of prediction performance was found as 78.47%

Figure 48 provides information about ANFIS predicted and observed values of total number of adverse events for Afghanistan and the regions of central, eastern, and north eastern and Figure 49 provides same information type for the regions of north western, south eastern, south western and western.

Table 34: Total number of adverse events – ANFIS best configuration for each region based on membership function type and its number

M.F. Type	**# of M.F.**	**Mean Absolute Error (MAE)**							
		Afgh.	**Central**	**Eastern**	**N.E.**	**S.E.**	**West.**	**N.W.**	**S.W.**
dsigmf	2	0.5866	0.4589	0.602	0.379	0.6992	0.6005	0.3986	0.9588
	3	0.7487	0.4427	0.621	0.456	0.7139	1.1517	0.4060	1.3567
	4	10.661	0.4910	0.634	2522.21	1.2036	23.37	0.4047	19.03
	5	2.35	2.1997	0.959	3.178	9.0648	0.9876	0.4334	1.5280
	6	12.764	0.4519	0.635	3.178	2.2203	0.8885	0.4880	3.6950
gauss2mf	2	0.5815	0.4687	0.601	0.385	0.6984	0.6005	0.3997	0.9653
	3	3.37	0.4418	0.641	66.063	0.7502	1.0786	0.4094	1.8675
	4	1.8363	0.4750	0.664	6345.02	7.9419	1.2147	0.5754	12.163
	5	2.7682	0.9959	0.811	1206.62	7.8829	0.7532	0.7313	1.8643
	6	12.563	0.4474	0.639	7275.15	2.2275	0.9363	0.8946	2.7540
gaussmf	2	0.5923	0.4431	0.603	0.384	0.7168	0.6079	0.3997	0.9681
	3	0.6108	0.4698	0.622	0.438	0.7135	0.9995	0.5167	1.2293
	4	1.1328	0.6875	0.604	1.368	1.3327	2.3646	0.4713	3.7042
	5	25.59	1.2844	1.445	1206.62	4.2901	5.4824	0.4749	85.455

M.F. Type	# of M.F.	Mean Absolute Error (MAE)							
		Afgh.	Central	Eastern	N.E.	S.E.	West.	N.W.	S.W.
	6	2.9016	0.4728	0.653	7275.15	3.4639	0.8201	0.4846	14.782
gbellmf	2	0.5876	0.4598	0.603	0.384	0.6979	0.6028	0.3990	0.9657
	3	0.6168	0.4396	0.621	0.435	0.7632	0.8623	0.4827	1.4168
	4	3.2685	0.5541	0.667	23.725	1.5481	2.2008	0.4444	5.0914
	5	6.613	1.5279	3.093	1206.62	4.5864	8.4171	0.4624	31.490
	6	12.523	0.4574	0.645	7275.15	2.6288	0.8217	0.4814	7.3784
pimf	2	0.5789	0.4512	0.599	0.383	0.7077	0.5998	0.3983	0.9485
	3	0.6617	0.4394	0.608	2.699	0.7376	0.7651	0.3989	1.1301
	4	0.7115	0.4495	0.681	443.64	0.7295	0.6071	0.3984	0.9848
	5	0.6456	0.4453	0.613	1206.62	0.7170	0.6252	0.4002	1.0273
	6	0.6015	0.4479	0.640	7275.15	0.7343	0.6128	0.4002	1.0205
psigmf	2	0.5866	0.4586	0.602	0.373	0.6992	0.6005	0.3978	0.9588
	3	0.7616	0.4481	0.640	0.430	0.7139	1.1517	0.4067	1.5532
	4	10.841	0.4935	0.639	4311.70	1.2036	23.061	0.3972	45.844
	5	2.6808	1.9951	1.200	0.399	9.0648	0.9876	0.4841	1.9615
	6	12.928	0.4549	0.639	0.399	2.2013	0.8885	0.5781	4.8239
trapmf	2	0.5813	0.4389	0.600	0.386	0.6998	0.6008	0.3985	0.9358
	3	1.0266	0.4399	0.611	1.714	0.7434	0.6343	0.3995	1.0157
	4	0.6388	0.4545	0.650	3362.50	0.7230	0.6071	0.3981	0.9925
	5	0.5949	0.4469	0.611	28.748	0.7167	0.6292	0.4002	0.9916
	6	0.6012	0.4487	0.623	2373.23	0.7301	0.6128	0.4002	1.0067
trimf	2	1.3947	1.4233	0.629	0.402	1.7825	0.7910	0.4428	2.2552
	3	0.6012	0.4498	0.604	1.758	0.7435	0.7361	0.4079	1.0313
	4	0.6969	0.4987	0.608	5406.25	0.8038	0.6490	0.4480	1.2633
	5	1.2727	0.4626	0.721	1142.45	7.8520	0.7312	0.4486	1.3481
	6	0.6609	0.4655	0.622	3.178	0.9162	0.7871	0.4505	2.2570

Table 35: ANFIS best model configuration for total number of adverse events in each region

Region	MAE	Prediction performance	Membership function	Number of membership function
Afghanistan	0.5799	85.604%	pimf	2
Central	0.4389	88.333%	trapmf	2
Eastern	0.5996	87.501%	pimf	2
North Eastern	0.3725	89.676%	psigmf	2
Western	0.5998	83.169%	pimf	2
South Eastern	0.6979	84.139%	gbell	2
South Western	0.9358	78.471%	trapmf	2
North Western	0.3972	90.454%	psigmf	4

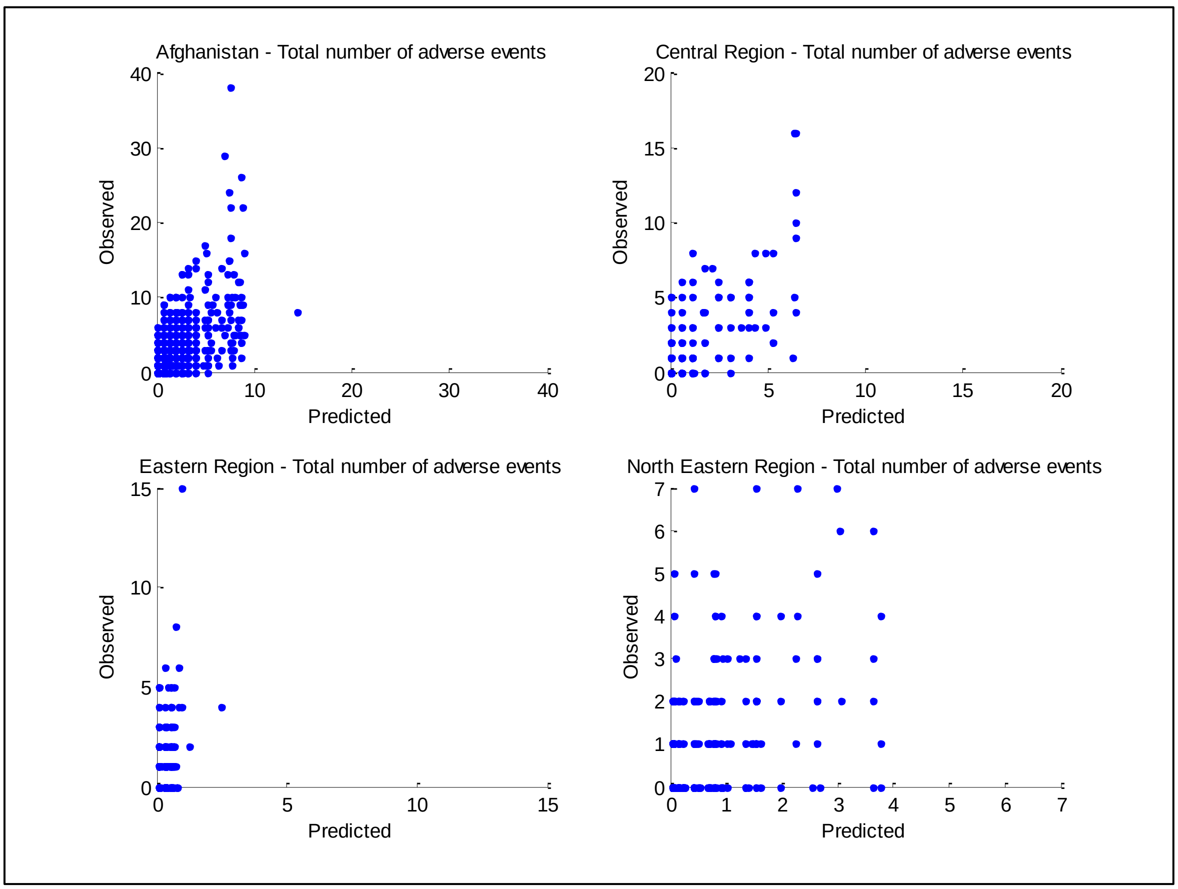


Figure 48: ANFIS predicted and observed values of total number of adverse events for Afghanistan, and central, eastern, and north eastern regions

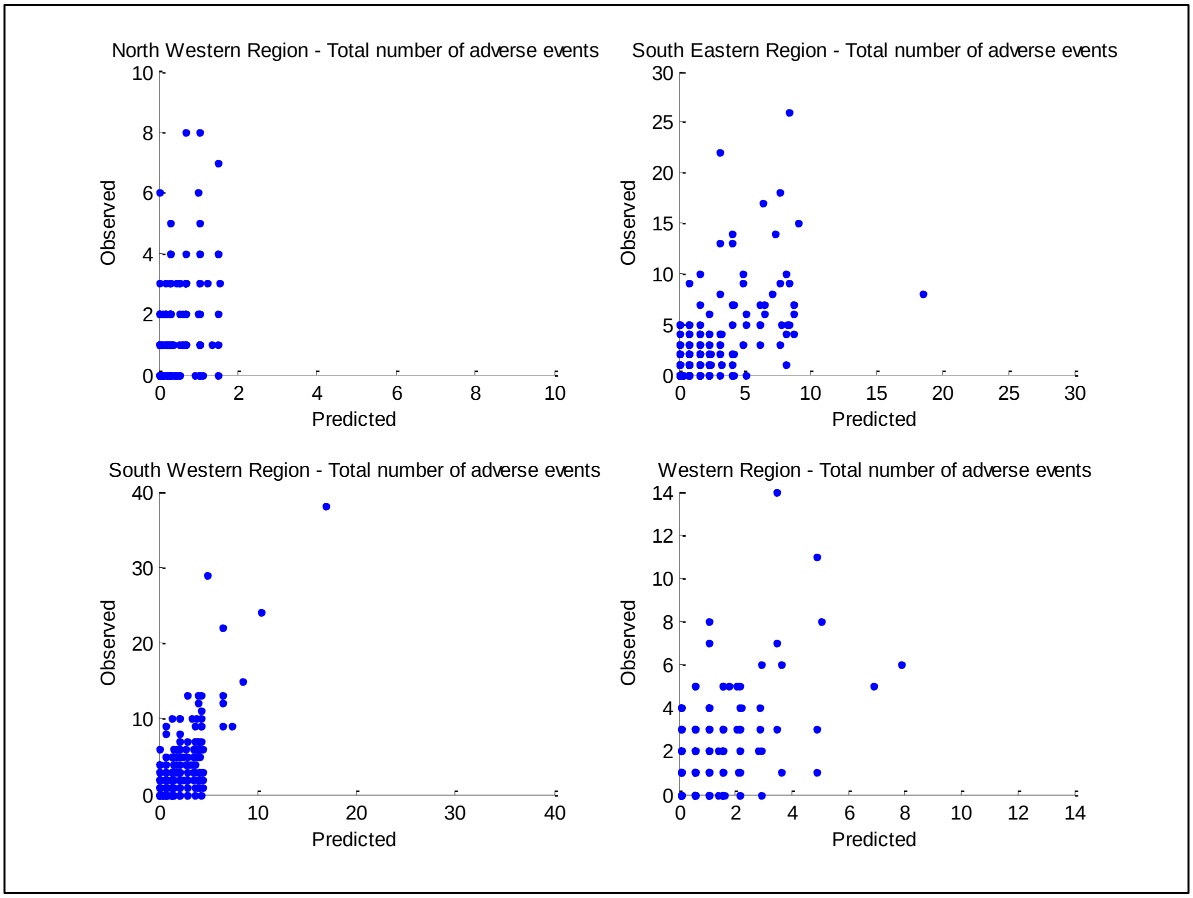


Figure 49: ANFIS predicted and observed values of total number of adverse events for north western, south eastern, south western, and western regions

4.4 Performance Comparison of Models

The performance values for incident types (number of people killed, wounded, and hijacked) and total number of adverse events was found from testing dataset using ANN, FIS, and ANFIS are given as follows:

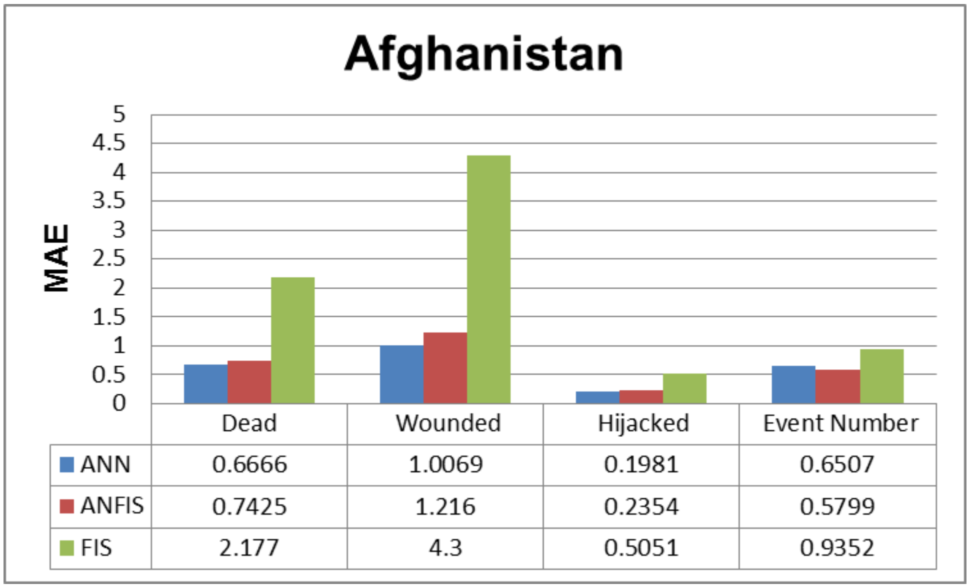


Figure 50: MAE values of predicted values for Afghanistan

For Afghanistan, while the MAE values of number of people killed, wounded, hijacked, and total number of adverse events output for ANN model was found as 0.6666, 1.0069, 0.1981, and 0.6587 respectively, these values were found in ANFIS model as 0.7425, 1.216, 0.2354, and 0.5799, and for FIS model as 2.177, 4.3, 0.5051, and 0.9352 (Figure 50).

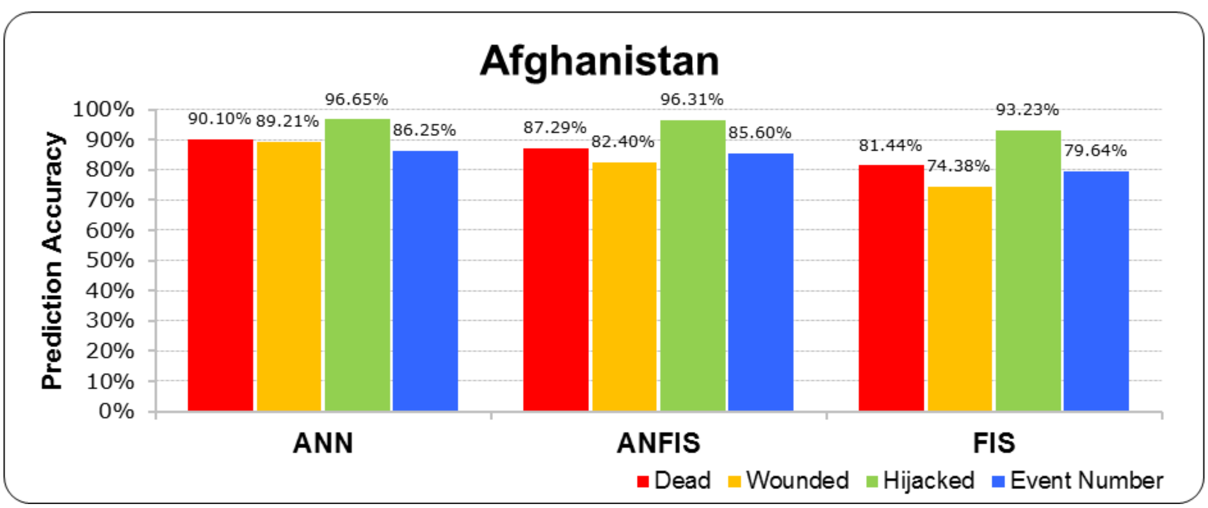
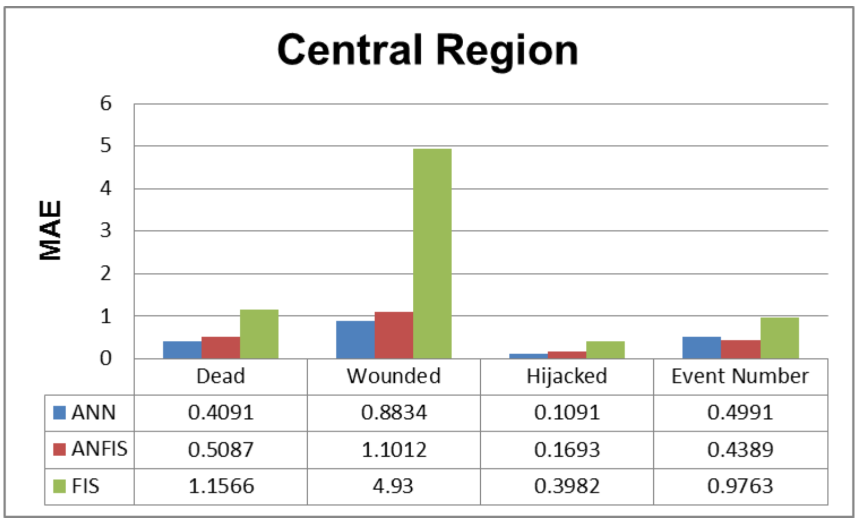


Figure 51: Percentage values of model prediction accuracy for Afghanistan

While the prediction accuracy percentage values of number of people killed, wounded, hijacked, and total number of adverse events output for ANN model was found as 90.10%, 89.21%, 96.65%, and 86.25% respectively, these values were found in ANFIS model as 87.29%, 82.40%, 96.31%, and 85.60%, and for FIS model as 81.44%, 74.38%, 93.23%, and 79.64% (Figure 51).



	Dead	Wounded	Hijacked	Event Number
ANN	0.4091	0.8834	0.1091	0.4991
ANFIS	0.5087	1.1012	0.1693	0.4389
FIS	1.1566	4.93	0.3982	0.9763

Figure 52: MAE values of predicted values for central region

For central region, while the MAE values of number of people killed, wounded, hijacked, and total number of adverse events output for ANN model was found as 0.4091, 0.8834, 0.1091, and 0.4991 respectively, these values were found in ANFIS model as 0.5087, 1.1012, 0.1693, and 0.4389, and for FIS model as 1.1566, 4.93, 0.3982, and 0.9763 (Figure 52).

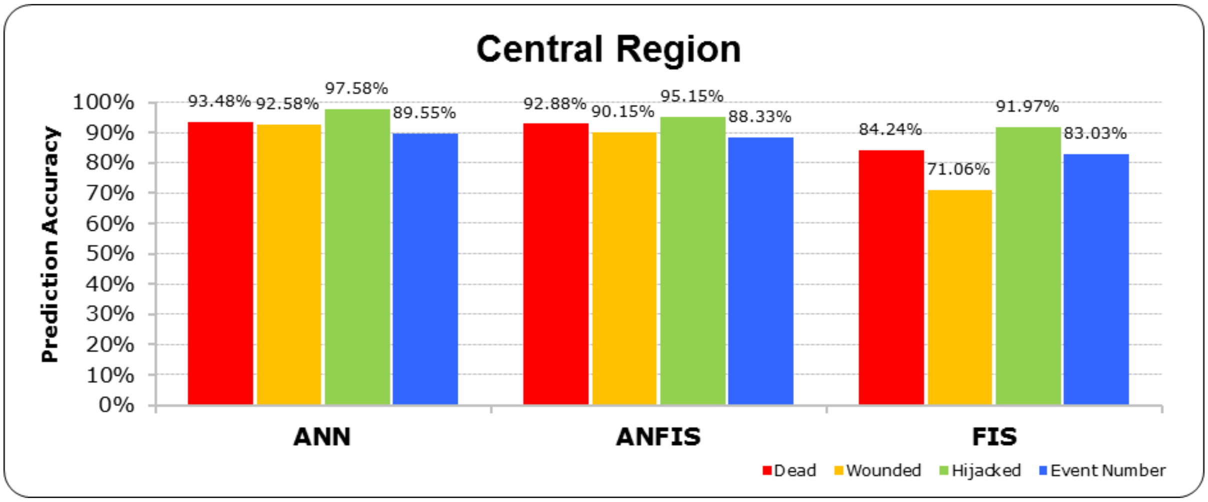
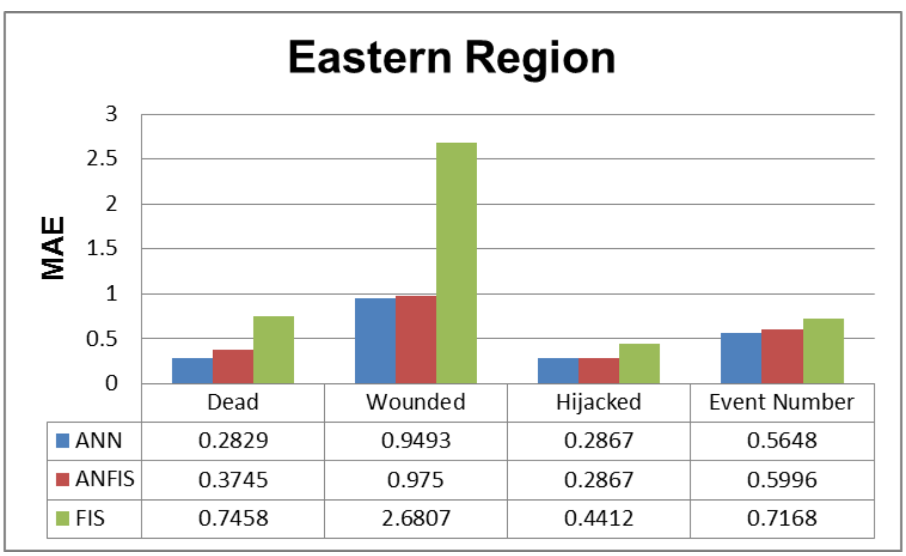


Figure 53: Percentage values of model prediction accuracy for central region

While the prediction accuracy percentage values of number of people killed, wounded, hijacked, and total number of adverse events output for ANN model was found as 93.48%, 92.58%, 97.58%, and 89.55% respectively, these values were found in ANFIS model as 92.88%, 90.15%, 95.15%, and 88.33%, and for FIS model as 84.24%, 71.06%, 91.97%, and 83.03% (Figure 53).



	Dead	Wounded	Hijacked	Event Number
ANN	0.2829	0.9493	0.2867	0.5648
ANFIS	0.3745	0.975	0.2867	0.5996
FIS	0.7458	2.6807	0.4412	0.7168

Figure 54: MAE values of predicted values for eastern region

For Eastern Afghanistan, while the MAE values of number of people killed, wounded, hijacked, and total number of adverse events output for ANN model was found as 0.2829, 0.9493, 0.2867, and 0.5648 respectively, these values were found in ANFIS model as 0.3745, 0.975, 0.2867, and 0.5996, and for FIS model as 0.7458, 2.6807, 0.4412, and 0.7168 (Figure 54).

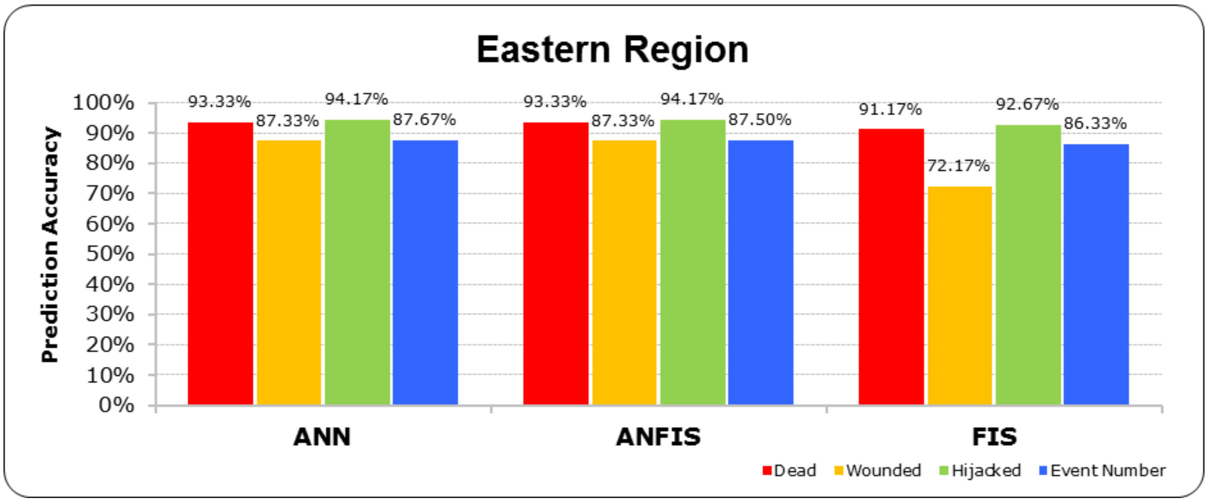


Figure 55: Percentage values of model prediction accuracy for eastern region

While the prediction accuracy percentage values of number of people killed, wounded, hijacked, and total number of adverse events output for ANN model was found as 93.33%, 87.33%, 94.17%, and 87.67% respectively, these values were found in ANFIS model as 93.33%, 87.33%, 94.17%, and 87.50%, and for FIS model as 91.17%, 72.17%, 92.67%, and 86.33% (Figure 55).

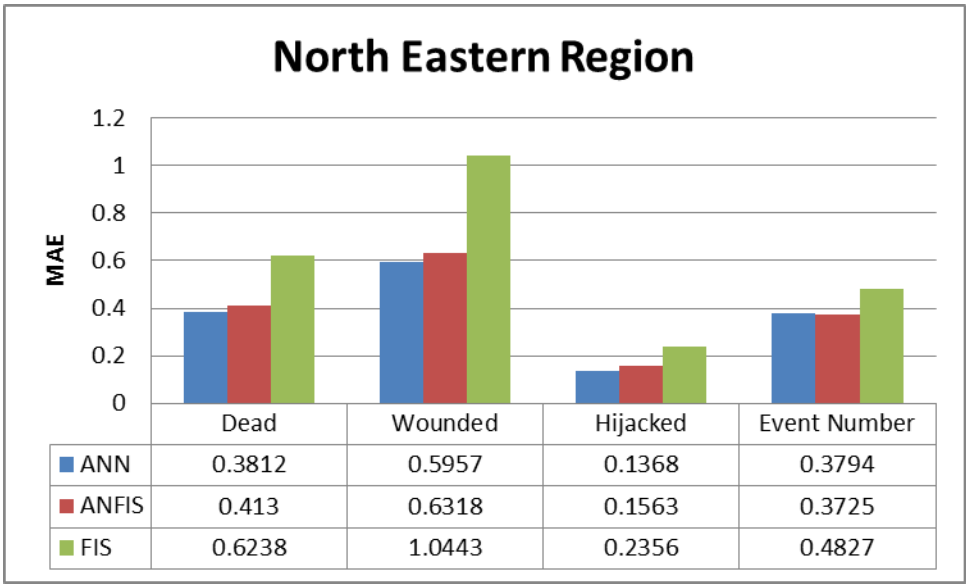


Figure 56: MAE values of predicted values for north eastern region

For North Eastern Afghanistan, while the MAE values of number of people killed, wounded, hijacked, and total number of adverse events output for ANN model was found as 0.3812, 0.5917, 0.1368, and 0.3794 respectively, these values were found in ANFIS model as 0.413, 0.6318, 0.1563, and 0.3725, and for FIS model as 0.6238, 1.0443, 0.2356, and 0.4827 (Figure 56).

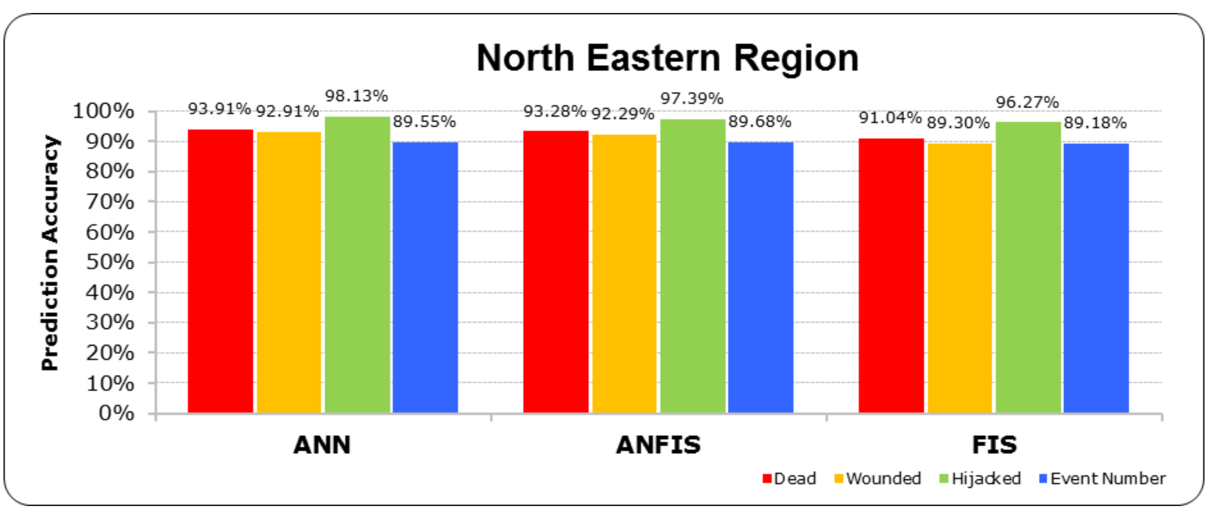
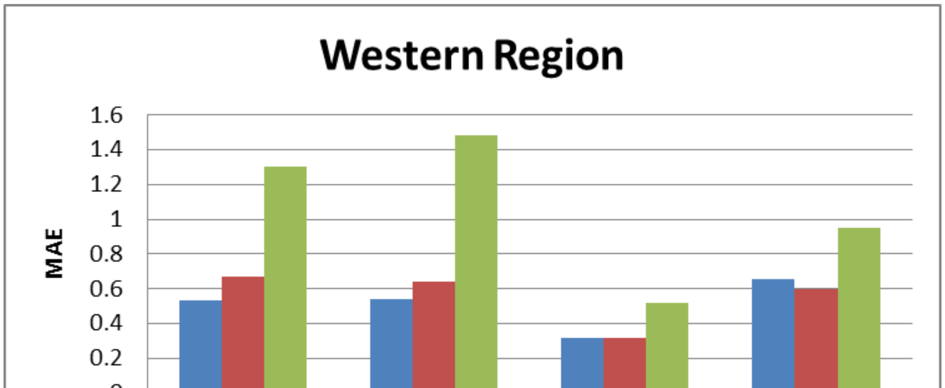


Figure 57: Percentage values of model prediction accuracy for north eastern region

While the prediction accuracy percentage values of number of people killed, wounded, hijacked, and total number of adverse events output for ANN model was found as 93.91%, 92.91%, 98.13%, and 89.55% respectively, these values were found in ANFIS model as 93.28%, 92.29%, 97.39%, and 89.68%, and for FIS model as 91.04%, 89.30%, 96.27%, and 89.18% (Figure 57).



	Dead	Wounded	Hijacked	Event Number
ANN	0.5357	0.537	0.3154	0.659
ANFIS	0.6722	0.6442	0.3199	0.5998
FIS	1.3051	1.4825	0.5161	0.9506

Figure 58: MAE values of predicted values for western region

For Western region, while the MAE values of number of people killed, wounded, hijacked, and total number of adverse events output for ANN model was found as 0.5357, 0.537, 0.3154, and 0.659 respectively, these values were found in ANFIS model as 0.6722, 0.6442, 0.3199, and 0.5998, and for FIS model as 1.3051, 1.4825, 0.5161, and 0.9506 (Figure 58).

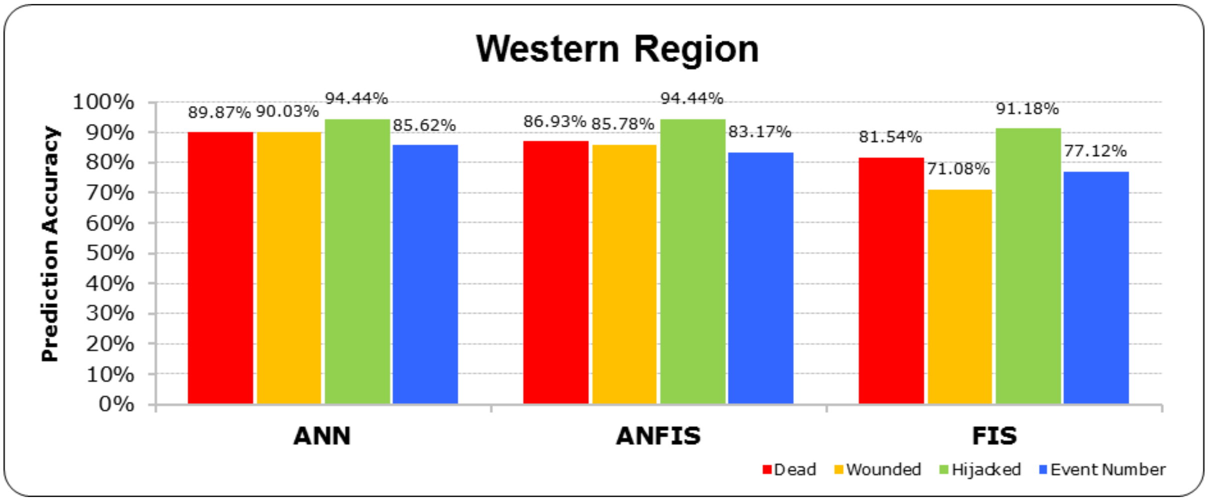


Figure 59: Percentage values of model prediction accuracy for western region

While the prediction accuracy percentage values of number of people killed, wounded, hijacked, and total number of adverse events output for ANN model was found as 89.87%, 90.03%, 94.44%, and 85.62% respectively, these values were found in ANFIS model as 86.93%, 85.78%, 94.44%, and 83.17%, and for FIS model as 81.54%, 71.08%, 91.18%, and 77.12% (Figure 59).

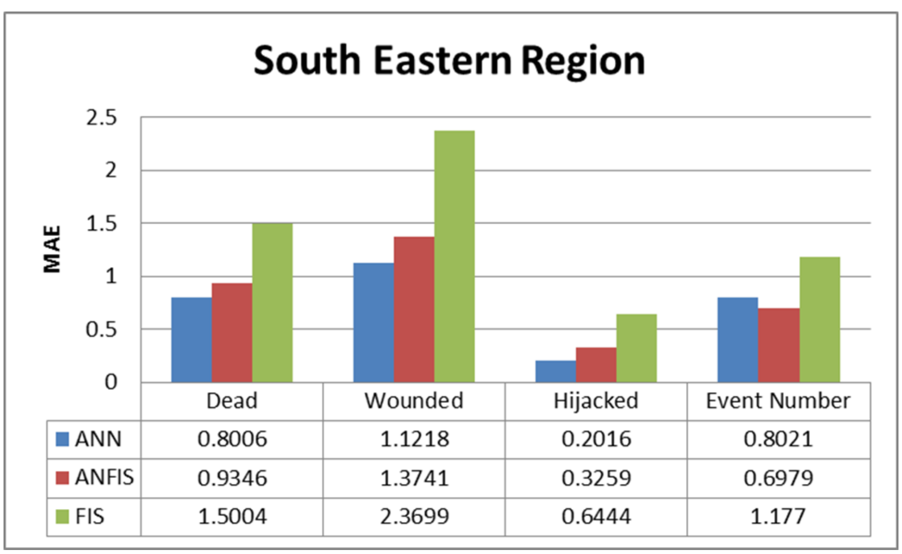


Figure 60: MAE values of predicted values for south eastern region

For South Eastern region, while the MAE values of number of people killed, wounded, hijacked, and total number of adverse events output for ANN model was found as 0.8006, 1.1218, 0.2016, and 0.8021 respectively, these values were found in ANFIS model as 0.9346, 1.3741, 0.3259, and 0.6979, and for FIS model as 1.5004, 2.3699, 0.6444, and 1.177 (Figure 60).

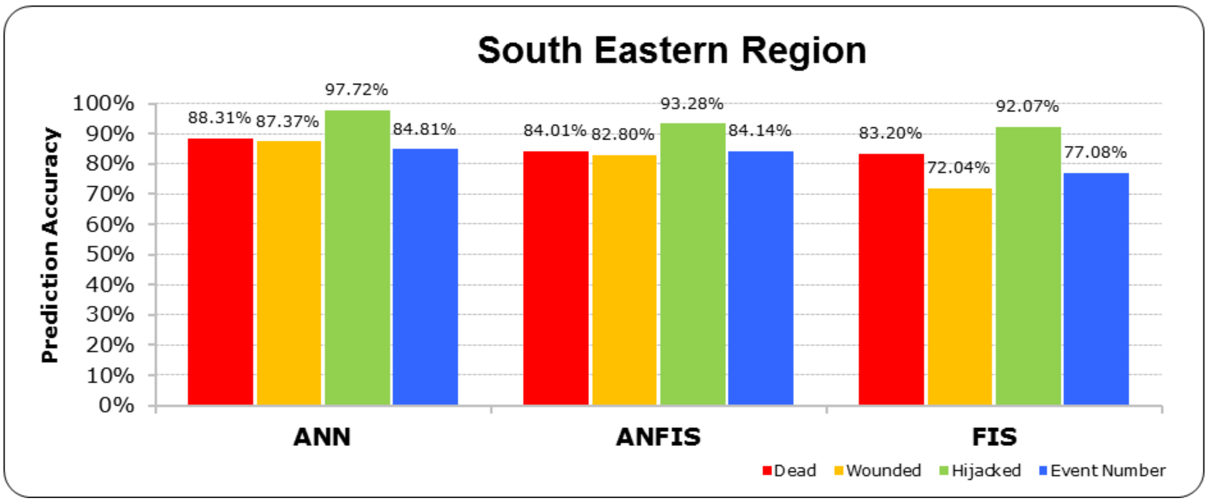


Figure 61: Percentage values of model prediction accuracy for south eastern region

While the prediction accuracy percentage values of number of people killed, wounded, hijacked, and total number of adverse events output for ANN model was found as 88.31%, 87.37%, 97.72%, and 84.81% respectively, these values were found in ANFIS model as 84.01%, 82.80%, 93.28%, and 84.14%, and for FIS model as 83.20%, 72.04%, 92.07%, and 77.08% (Figure 61).

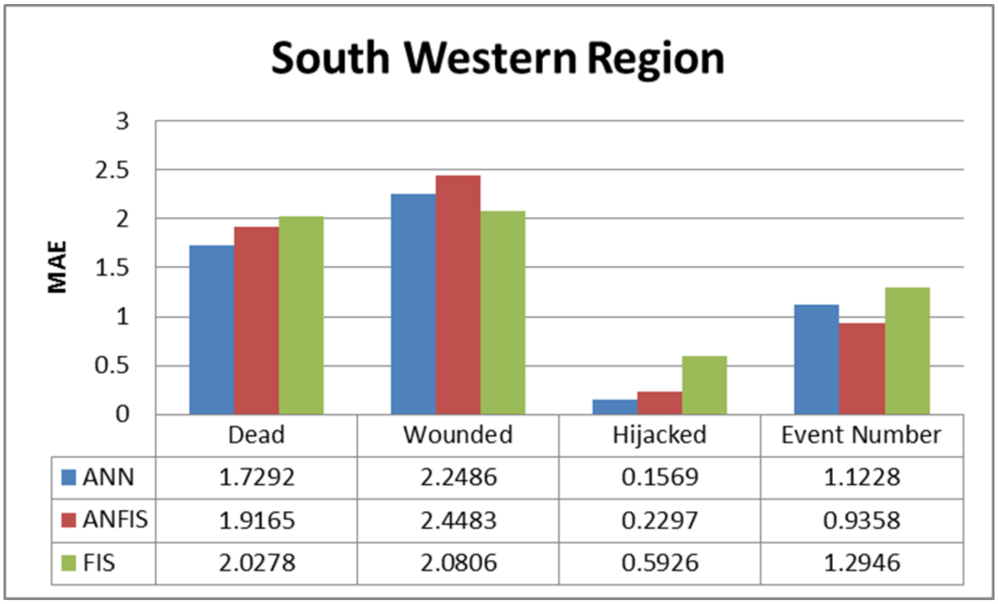


Figure 62: MAE values of predicted values for south western region

For South Western region, while the MAE values of number of people killed, wounded, hijacked, and total number of adverse events output for ANN model was found as 1.7292, 2.2486, 0.1569, and 1.1228 respectively, these values were found in ANFIS model as 1.9165, 2.4483, 0.2297, and 0.9358, and for FIS model as 2.0278, 2.0806, 0.5926, and 1.2946 (Figure 62).

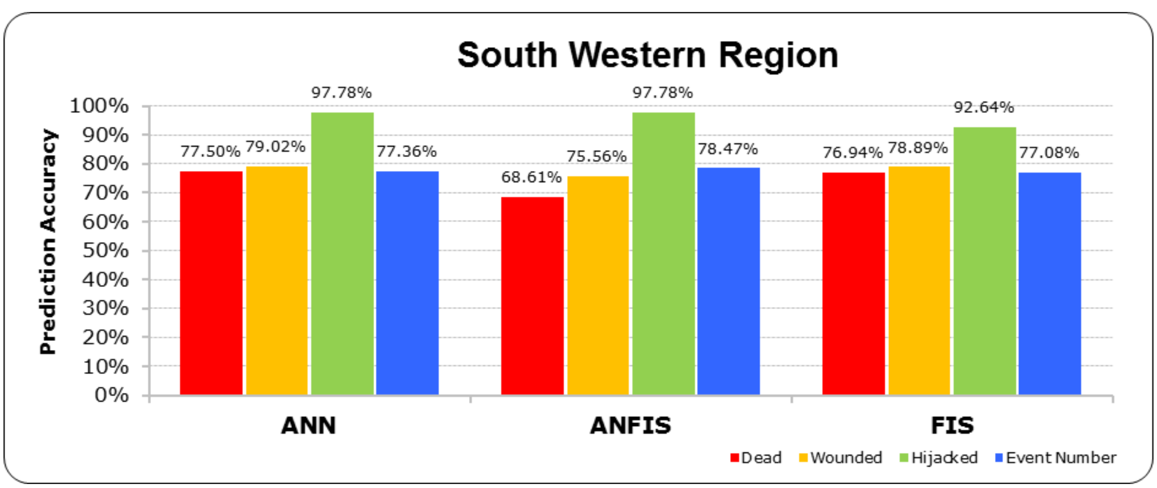
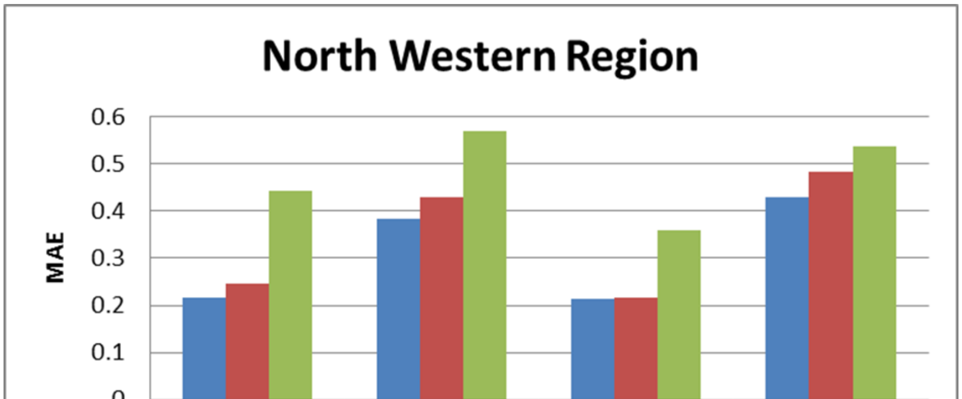


Figure 63: Percentage values of model prediction accuracy for south western region

While the prediction accuracy percentage values of number of people killed, wounded, hijacked, and total number of adverse events output for ANN model was found as 77.50%, 79.02%, 97.78%, and 77.36% respectively, these values were found in ANFIS model as 68.61%, 75.56%, 97.78%, and 78.47%, and for FIS model as 76.94%, 78.89%, 92.64%, and 77.08% (Figure 63).



	Dead	Wounded	Hijacked	Event Number
ANN	0.2167	0.3833	0.2136	0.4303
ANFIS	0.2449	0.4295	0.2162	0.4841
FIS	0.4419	0.5694	0.36	0.5362

Figure 64: MAE values of predicted values for north western region

For North Western region, while the MAE values of number of people killed, wounded, hijacked, and total number of adverse events output for ANN model was found as 0.2167, 0.3833, 0.2136, and 0.4303 respectively, these values were found in ANFIS model as 0.2449, 0.4295, 0.2162, and 0.4841, and for FIS model as 0.4419, 0.5694, 0.36, and 0.5362 (Figure 64).

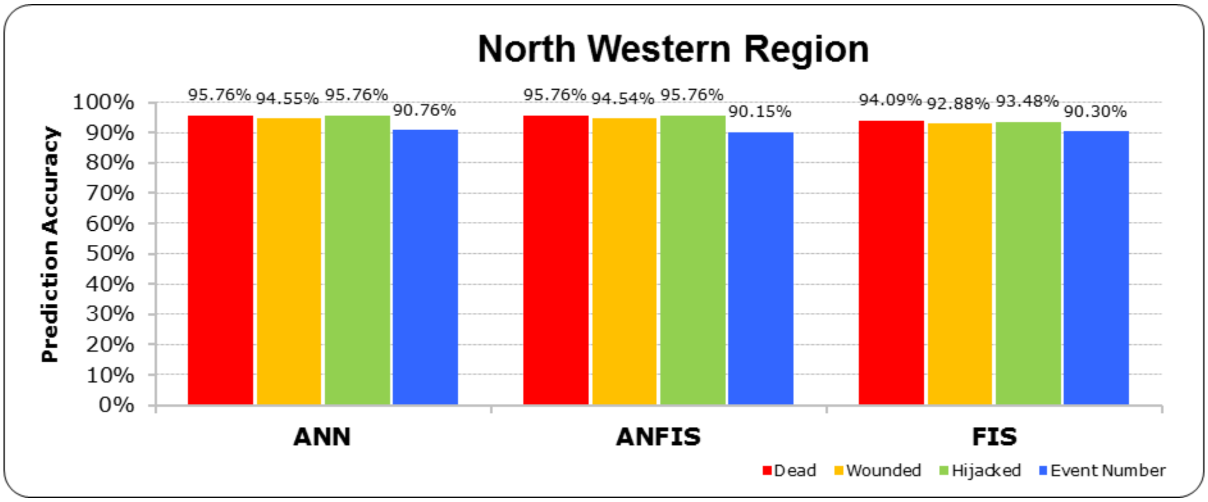


Figure 65: Percentage values of model prediction accuracy for north western region

While the prediction accuracy percentage values of number of people killed, wounded, hijacked, and total number of adverse events output for ANN model was found as 95.76%, 94.55%, 95.76%, and 90.76% respectively, these values were found in ANFIS model as 95.76%, 94.54%, 95.76%, and 90.15%, and for FIS model as 94.09%, 92.88%, 93.48%, and 90.30% (Figure 65).

To determine the most accurate approach amongst the three methodologies applied in this research, all models under specific region were compared to each other on the same basis using mean absolute error (MAE) and percentage prediction performance values. When the model accuracy was calculated based on the MAE for each of the ninety-six models, ANN models had better predictive accuracy than ANFIS and FIS models in general as demonstrated by experimental results. Moreover, ANFIS models had better predictive accuracy than FIS models in general. Best prediction model for each region and dependent variable is summarized in Table 36. Based on Table 36, ANNs show better performance than ANFIS and FIS in all regions for number of people killed, wounded, and hijacked. For total number of adverse events, ANFIS show better performance than ANN and FIS in all regions except in eastern and south western regions. Most predicted results of ANNs were found between 0 and 1, this reduced the corresponding MAE values. These results show that ANNs dealt with zero values better than other approaches. One possible explanation for the superior performance of ANNs and ANFIS is that the learning ability of both approaches.

Table 36: Best prediction model for each region and dependent variable based on MAE values

	Number of people killed	Number of people wounded	Number of people hijacked	Total number of adverse events
Afghanistan	ANN	ANN	ANN	ANFIS
Central	ANN	ANN	ANN	ANFIS
Eastern	ANN	ANN	ANN	ANN
North Eastern	ANN	ANN	ANN	ANFIS
South Eastern	ANN	ANN	ANN	ANFIS
Western	ANN	ANN	ANN	ANFIS
North Western	ANN	ANN	ANN	ANFIS
South Western	ANN	ANN	ANN	ANN

To support predictive modeling and the main objective of the study, geographic information systems (GIS) was also implemented to visualize all model results. Monthly based model comparison results with observed values in district level for Afghanistan were mapped using the ESRI ArcGIS 10.1 programme (ESRI, 2012). As an illustration, Figure 66 provides information about predicted and observed values of number of people killed for each district in January 2010. All corresponding maps were represented in Appendix D (Figures 79 through 125). Furthermore, monthly prediction performance results were tabulated in regional base in Appendix E (Tables 54 through 85).

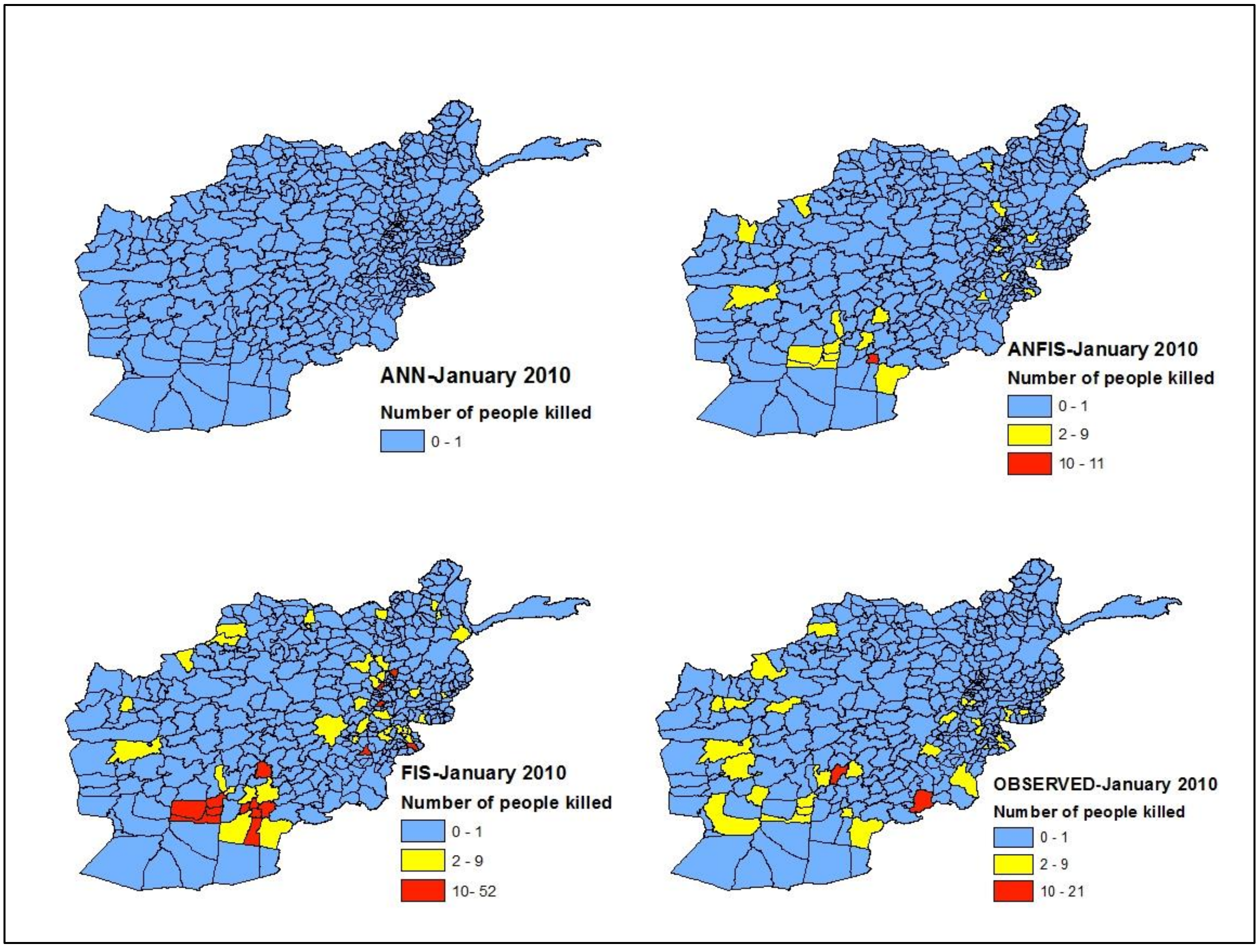


Figure 66: Predicted and observed values of number of people killed for each district in January 2010

The results show that the proposed ANN, FIS, and ANFIS models are encouraging in order to estimate the occurrence of adverse events based on the total budget of fourteen project types considered at years t=0 (i.e. current year), t-1 (previous year), and t-2 (two years ago); the total number of fourteen economic aid projects at years t=0 (i.e. current year), t-1 (previous year), and t-2 (two years ago); number of adverse events in previous month; urban and rural population density for male and female.

4.5 Sensitivity Analysis

In this research, sensitivity analysis was implemented as an approach to determine the cause and effect relationship between the input and output values. In previous section, ANN was selected as the best prediction model based on performance metrics. Therefore, sensitivity analysis was performed based on trained ANN (Figure 67) and developed under the NeuroSolutions v.6.20.

In sensitivity analysis, a matrix of values is created containing information for each input/output combination computed as a percentage such that the sum of all sensitivity values for a particular output totals 100% (NeuroSolutions documentation). Sensitivity analysis was applied to identify the degree at which independent variables (inputs or adverse events at time previous month, development projects and number of projects at t, t-1, and t-2, and population density) contributes to the determination of dependent variables (outputs or adverse events at time t+1).

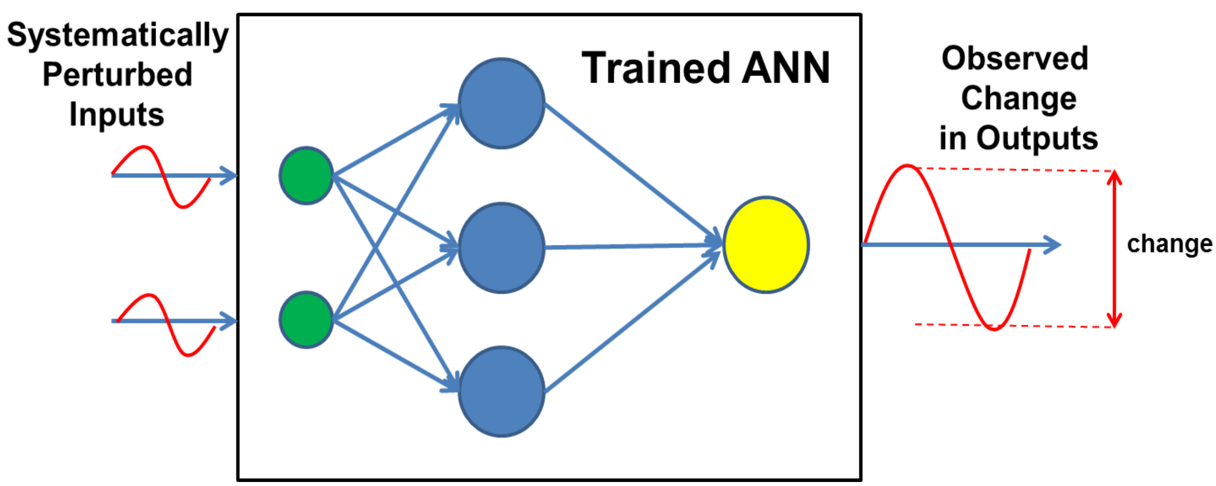


Figure 67: Sensitivity analysis on trained ANN

(Adapted from Turban et al., 2007)

While evaluating sensitivity analysis, the learning unit needs to be off mode in order that the network weights are unchanged. The main purpose is to track the percentage change in the output value after a little change in the input value (Principe et al. 2000).

Except the first input value, remaining input values are not changed based on their mean values. The output value is calculated based on the percentage change of corresponding mean value. The calculation step is repeated and summarized for each input and output value based on the variation difference (Sharda and Delen, 2006).

Sensitivity values represent the significance of each independent variable on dependent variable. For each dependent variable, the independent variables that produce low sensitivity values can be considered as less significant variable than the independent variables that produce high sensitivity values. All eighty-nine independent variables were ranked based on sensitivity value to represent the importance of each independent variable on dependent variable. As an illustration, Table 37 provides information about the rank of all input values for number of people killed in central region. Based on Table 37, urban female population density is the most significant variable and number of emergency assistance project at year (t-1) was found as the least significant variable. For other regions and dependent variables, the ranking of independent variables are tabulated in Appendix F (Tables 86 through 112).

Table 37: The sensitivity rank of all input values for number of people killed in central region

Central Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
1	Urban female population density	0.014557
2	Urban male population density	0.014209
3	Number of commerce and industry project at year (t-1)	0.008866
4	Number of environment project at year (t-2)	0.008573
5	Environment project budget at year (t)	0.007192

Central Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
6	Number of people killed at month (t-1)	0.007029
7	Number of environment project at year (t)	0.006721
8	Number of security project at year (t)	0.006685
9	Water and sanitation project budget at year (t-1)	0.006611
10	Number of energy project at year (t-1)	0.006256
11	Community development project budget at year (t-1)	0.006168
12	Number of capacity building project at year (t-2)	0.006058
13	Community development project budget at year (t-2)	0.005964
14	Number of emergency assistance project at year (t)	0.005398
15	Number of governance project at year (t)	0.005139
16	Health project budget at year (t-2)	0.004658
17	Community development project budget at year (t)	0.004358
18	Number of security project at year (t-2)	0.004323
19	Security project budget at year (t-1)	0.004299
20	Number of Community development project at year (t)	0.004274
21	Health project budget at year (t-1)	0.004215
22	Capacity building project budget at year (t-1)	0.004034
23	Emergency assistance project budget at year (t-2)	0.003909
24	Number of governance project at year (t-1)	0.003813
25	Number of security project at year (t-1)	0.003774
26	Governance project budget at year (t)	0.003646
27	Number of capacity building project at year (t)	0.003643
28	Number of Community development project at year (t-1)	0.003632
29	Energy project budget at year (t-2)	0.003543
30	Gender project budget at year (t-2)	0.003431
31	Number of commerce and industry project at year (t-2)	0.003286
32	Number of agriculture project at year (t-1)	0.003108
33	Capacity building project budget at year (t)	0.00298
34	Number of transport project at year (t-2)	0.002926
35	Education project budget at year (t-1)	0.002867
36	Gender project budget at year (t)	0.002836
37	Governance project budget at year (t-2)	0.002806
38	Transport project budget at year (t-2)	0.002723
39	Emergency assistance project budget at year (t-1)	0.002675
40	Number of energy project at year (t-2)	0.002674
41	Number of water and sanitation project at year (t-2)	0.002616
42	Number of emergency assistance project at year (t-2)	0.002588
43	Number of transport project at year (t)	0.002587
44	Number of gender project at year (t)	0.002557
45	Emergency assistance project budget at year (t)	0.002461

Central Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
46	Number of energy project at year (t)	0.002369
47	Number of education project at year (t-2)	0.002361
48	Environment project budget at year (t-1)	0.002307
49	Governance project budget at year (t-1)	0.002265
50	Energy project budget at year (t)	0.002225
51	Security project budget at year (t)	0.002198
52	Health project budget at year (t)	0.002187
53	Number of health project at year (t)	0.00215
54	Education project budget at year (t)	0.002049
55	Gender project budget at year (t-1)	0.002018
56	Capacity building project budget at year (t-2)	0.001935
57	Education project budget at year (t-2)	0.001868
58	Rural female population density	0.001839
59	Number of agriculture project at year (t)	0.001798
60	Rural male population density	0.001768
61	Water and sanitation project budget at year (t-2)	0.001707
62	Number of environment project at year (t-1)	0.001605
63	Number of gender project at year (t-2)	0.001485
64	Environment project budget at year (t-2)	0.001426
65	Number of health project at year (t-1)	0.001407
66	Number of education project at year (t-1)	0.001392
67	Transport project budget at year (t-1)	0.001342
68	Number of transport project at year (t-1)	0.00115
69	Number of agriculture project at year (t-2)	0.001135
70	Transport project budget at year (t)	0.001111
71	Commerce and industry project budget at year (t-1)	0.001106
72	Number of governance project at year (t-2)	0.001105
73	Agriculture project budget at year (t-1)	0.00092
74	Water and sanitation project budget at year (t)	0.000863
75	Commerce and industry project budget at year (t-2)	0.00086
76	Energy project budget at year (t-1)	0.000818
77	Number of commerce and industry project at year (t)	0.000807
78	Number of education project at year (t)	0.000792
79	Number of capacity building project at year (t-1)	0.000672
80	Security project budget at year (t-2)	0.000584
81	Number of water and sanitation project at year (t-1)	0.000577
82	Commerce and industry project budget at year (t)	0.000496
83	Number of gender project at year (t-1)	0.000489
84	Agriculture project budget at year (t)	0.000451
85	Number of water and sanitation project at year (t)	0.000403

Central Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
86	Agriculture project budget at year (t-2)	0.000375
87	Number of Community development project at year (t-2)	0.000283
88	Number of health project at year (t-2)	0.000255
89	Number of emergency assistance project at year (t-1)	0.000106

To represent the effect of the most important variables, top ten independent variables among 89 inputs on each dependent variable was represented. This analyis was repeated for four dependent variables of seven regions. The effect of each of the input values on the output values was investigated and the corresponding results of each region were represented in Tables 38 through 44. The results basically highlighted the importance of independent variables that were ranked within top ten parameters.

As it is shown in following tables; the independent variables are ranked from 1 to 10 to represent the majority of high values that belong to different parameters based on a dependent variable which means that these values have the highest impact on adverse event numbers in a decreased or increased way. After an increment in the input value, the output value is increased or decreased.

As shown in tables, the most important parameter of a specific model among top ten parameters can be the least important parameter of the top ten ranking in other regions for the corresponding dependent variable. For instance, the effect of urban female population density was ranked as the first parameter on number of people killed in central region. However, it was found as the least important parameter on the corresponding dependent variable of eastern region. This difference might be interpreted as the higher urban female population density in central region than eastern region.

Based on the results for central region (Table 38), the parameters namely, urban female and male population density were found to be the most effective variables. These two variables were ranked within top 5 parameters for all dependent variables of central region. Highly populated Kabul city is located in central region. This can be the reason of the effect of population density on dependent variables.

When the same dependent variables of seven regions were considered together, some project types were found more sensitive on dependent variables than others. For instance, the projects in transportation sector were appeared more than other projects when the dependent variables were selected as number of people killed and wounded. Moreover, the relationship of transportation projects was found positive that the importance of number and budget amount of transportation projects increases with the increased number of people killed and was found negative that the importance of aid number and budget amount of transportation projects increases with the decreased number of people wounded.

For number of people hijacked and total number of adverse events, the projects related to community development were appeared more than other types of projects. Totally ten community development projects were listed as independent variables that affect number of people hijacked in seven regions. Seven out of ten community development projects were observed in north western and north eastern regions and the relationship of these projects was found negative that the importance of aid number and budget amount increases with the decreased number of people hijacked.

Table 38: The rank of inputs and their effect on dependent variables of central region

Output	Rank	Input values	Input	Output
Number of people killed	1	Urban female population density	Increased	Increased
	2	Urban male population density	Increased	Increased
	3	Number of commerce and industry at year (t-1)	Increased	Increased
	4	Number of environment project at year (t-2)	Increased	Increased
	5	Environment project budget at year (t)	Increased	Decreased
	6	Number of people killed at month (t-1)	Increased	Decreased
	7	Number of environment project at year (t)	Increased	Decreased
	8	Number of security project at year (t)	Increased	Decreased
	9	Water and sanitation project budget at year (t-1)	Increased	Decreased
	10	Number of energy project at year (t-1)	Increased	Increased
Number of people wounded	1	Urban female population density	Increased	Increased
	2	Number of water and sanitation at year (t-2)	Increased	Increased
	3	Number of gender project at year (t-2)	Increased	Increased
	4	Number of commerce and industry at year (t-1)	Increased	Increased
	5	Number of capacity building at year (t-2)	Increased	Increased
	6	Number of security project at year (t-2)	Increased	Increased
	7	Health project budget at year (t-2)	Increased	Increased
	8	Health project budget at year (t)	Increased	Increased
	9	Number of capacity building at year (t-1)	Increased	Increased
	10	Water and sanitation project budget at year (t-2)	Increased	Increased
Number of people hijacked	1	Urban female population density	Increased	Increased
	2	Number of education project at year (t-1)	Increased	Increased
	3	Agriculture project budget at year (t-2)	Increased	Increased
	4	Water and sanitation project budget at year (t)	Increased	Increased
	5	Number of water and sanitation at year (t-2)	Increased	Increased
	6	Number of education project at year (t)	Increased	Increased
	7	Number of education project at year (t-2)	Increased	Increased
	8	Number of health project at year (t-1)	Increased	Increased
	9	Community develop. project budget at year (t-2)	Increased	Increased
	10	Agriculture project budget at year (t)	Increased	Increased
Total number of adverse events	1	Total number of adverse events at month (t-1)	Increased	Increased
	2	Number of commerce and industry at year (t-1)	Increased	Increased
	3	Urban male population density	Increased	Increased
	4	Urban female population density	Increased	Increased
	5	Gender project budget at year (t-2)	Increased	Decreased
	6	Number of education project at year (t-2)	Increased	Increased
	7	Agriculture project budget at year (t)	Increased	Increased
	8	Health project budget at year (t)	Increased	Decreased
	9	Education project budget at year (t-1)	Increased	Decreased
	10	Transport project budget at year (t-2)	Increased	Increased

Table 39: The rank of inputs and their effect on dependent variables of eastern region

Output	Rank	Input values	Input	Output
Number of people killed	1	Number of transport project at year (t-2)	Increased	Increased
	2	Environment project budget at year (t-1)	Increased	Increased
	3	Number of transport project at year (t-1)	Increased	Increased
	4	Number of capacity building at year (t)	Increased	Increased
	5	Number of health project at year (t-2)	Increased	Increased
	6	Number of emergency assist. at year (t-2)	Increased	Increased
	7	Rural male population density	Increased	Increased
	8	Number of gender project at year (t)	Increased	Increased
	9	Number of capacity building at year (t-2)	Increased	Increased
	10	Urban female population density	Increased	Increased
Number of people wounded	1	Security project budget at year (t-2)	Increased	Decreased
	2	Water and sanitation proj. budget at year (t-1)	Increased	Decreased
	3	Number of transport project at year (t)	Increased	Decreased
	4	Number of environment project at year (t-1)	Increased	Increased
	5	Agriculture project budget at year (t-1)	Increased	Decreased
	6	Security project budget at year (t-1)	Increased	Increased
	7	Number of energy project at year (t)	Increased	Increased
	8	Health project budget at year (t-2)	Increased	Decreased
	9	Number of education project at year (t-1)	Increased	Decreased
	10	Health project budget at year (t)	Increased	Decreased
Number of people hijacked	1	Security project budget at year (t-2)	Increased	Decreased
	2	Education project budget at year (t)	Increased	Decreased
	3	Number of education project at year (t-2)	Increased	Decreased
	4	Number of gender project at year (t)	Increased	Decreased
	5	Gender project budget at year (t)	Increased	Increased
	6	Governance project budget at year (t-2)	Increased	Decreased
	7	Education project budget at year (t-2)	Increased	Increased
	8	Number of education project at year (t)	Increased	Decreased
	9	Number of security project at year (t)	Increased	Increased
	10	Number of people hijacked at month (t-1)	Increased	Decreased
Total number of adverse events	1	Number of transport project at year (t-2)	Increased	Increased
	2	Number of emergency assistance at year (t-1)	Increased	Increased
	3	Number of Community develop. at year (t)	Increased	Increased
	4	Number of Community develop. at year (t-2)	Increased	Increased
	5	Number of environment project at year (t-1)	Increased	Increased
	6	Capacity building project budget at year (t)	Increased	Decreased
	7	Emergency assist. project budget at year (t-2)	Increased	Increased
	8	Urban male population density	Increased	Increased
	9	Number of gender project at year (t-1)	Increased	Increased
	10	Number of Community develop. at year (t-1)	Increased	Increased

Table 40: The rank of inputs and their effect on dependent variables of north-eastern region

Output	Rank	Input values	Input	Output
Number of people killed	1	Security project budget at year (t)	Increased	Decreased
	2	Agriculture project budget at year (t-2)	Increased	Decreased
	3	Community dev. project budget at year (t-2)	Increased	Decreased
	4	Number of commerce and industry at year (t-2)	Increased	Decreased
	5	Number of environment project at year (t)	Increased	Decreased
	6	Gender project budget at year (t-2)	Increased	Decreased
	7	Number of community develop. at year (t-2)	Increased	Decreased
	8	Number of gender project at year (t-1)	Increased	Decreased
	9	Number of Community development at year (t)	Increased	Decreased
	10	Number of governance project at year (t)	Increased	Decreased
Number of people wounded	1	Transport project budget at year (t)	Increased	Decreased
	2	Transport project budget at year (t-1)	Increased	Decreased
	3	Transport project budget at year (t-2)	Increased	Decreased
	4	Number of transport project at year (t-2)	Increased	Decreased
	5	Number of transport project at year (t-1)	Increased	Decreased
	6	Water and sanitation proj. budget at year (t-2)	Increased	Decreased
	7	Number of emergency assistance at year (t-1)	Increased	Decreased
	8	Emergency assistance proj. budget at year (t-2)	Increased	Decreased
	9	Number of emergency assistance at year (t)	Increased	Decreased
	10	Number of gender project at year (t-2)	Increased	Decreased
Number of people hijacked	1	Transport project budget at year (t)	Increased	Decreased
	2	Transport project budget at year (t-1)	Increased	Decreased
	3	Community dev. project budget at year (t-1)	Increased	Decreased
	4	Capacity building project budget at year (t-2)	Increased	Decreased
	5	Number of community dev project at year (t-2)	Increased	Decreased
	6	Transport project budget at year (t-2)	Increased	Decreased
	7	Community dev. project budget at year (t-2)	Increased	Decreased
	8	Number of governance project at year (t-2)	Increased	Decreased
	9	Community dev. project budget at year (t)	Increased	Decreased
	10	Capacity building project budget at year (t-1)	Increased	Decreased
Total number of adverse events	1	Total number of adverse events at month (t-1)	Increased	Increased
	2	Number of commerce and industry at year (t-1)	Increased	Increased
	3	Health project budget at year (t)	Increased	Increased
	4	Number of agriculture project at year (t-1)	Increased	Increased
	5	Number of commerce and industry at year (t-2)	Increased	Increased
	6	Community dev. project budget at year (t-2)	Increased	Increased
	7	Number of education project at year (t)	Increased	Increased
	8	Urban male population density	Increased	Increased
	9	Number of community develop. at year (t-2)	Increased	Increased
	10	Gender project budget at year (t)	Increased	Increased

Table 41: The rank of inputs and their effect on dependent variables of north-western region

Output	Rank	Input values	Input	Output
Number of people killed	1	Urban male population density	Increased	Increased
	2	Community dev. project budget at year (t-2)	Increased	Increased
	3	Transport project budget at year (t-1)	Increased	Increased
	4	Number of agriculture project at year (t-1)	Increased	Increased
	5	Number of gender project at year (t-1)	Increased	Increased
	6	Education project budget at year (t-1)	Increased	Decreased
	7	Number of commerce and indust. at year (t-2)	Increased	Increased
	8	Number of water and sanitation at year (t-2)	Increased	Decreased
	9	Rural male population density	Increased	Increased
	10	Number of security project at year (t-1)	Increased	Decreased
Number of people wounded	1	Number of agriculture project at year (t-2)	Increased	Decreased
	2	Transport project budget at year (t)	Increased	Decreased
	3	Security project budget at year (t-1)	Increased	Decreased
	4	Number of water and sanitation at year (t-1)	Increased	Decreased
	5	Number of transport project at year (t-1)	Increased	Decreased
	6	Number of energy project at year (t-2)	Increased	Decreased
	7	Number of emergency assistance at year (t-2)	Increased	Decreased
	8	Agriculture project budget at year (t-2)	Increased	Decreased
	9	Rural male population density	Increased	Decreased
	10	Gender project budget at year (t-1)	Increased	Decreased
Number of people hijacked	1	Community dev. project budget at year (t)	Increased	Decreased
	2	Community dev. project budget at year (t-1)	Increased	Decreased
	3	Governance project budget at year (t)	Increased	Decreased
	4	Governance project budget at year (t-2)	Increased	Decreased
	5	Governance project budget at year (t-1)	Increased	Decreased
	6	Community dev. project budget at year (t-2)	Increased	Decreased
	7	Number of health project at year (t-2)	Increased	Decreased
	8	Capacity building project budget at year (t-2)	Increased	Decreased
	9	Commerce and ind. proj. budget at year (t-2)	Increased	Decreased
	10	Number of people hijacked at month (t-1)	Increased	Increased
Total number of adverse events	1	Community dev. project budget at year (t)	Increased	Decreased
	2	Community dev. project budget at year (t-1)	Increased	Decreased
	3	Community dev. project budget at year (t-2)	Increased	Decreased
	4	Governance project budget at year (t-1)	Increased	Decreased
	5	Governance project budget at year (t)	Increased	Decreased
	6	Number of com. and ind. proj.at year (t-2)	Increased	Decreased
	7	Number of health project at year (t-2)	Increased	Decreased
	8	Number of education project at year (t)	Increased	Decreased
	9	Governance project budget at year (t-2)	Increased	Decreased
	10	Community dev. project budget at year (t)	Increased	Decreased

Table 42: The rank of inputs and their effect on dependent variables of south eastern region

Output	Rank	Input values	Input	Output
Number of people killed	1	Number of people killed at month (t-1)	Increased	Increased
	2	Number of agriculture project at year (t-2)	Increased	Increased
	3	Number of commerce and ind. proj. at year (t-2)	Increased	Increased
	4	Gender project budget at year (t-1)	Increased	Increased
	5	Number of governance project at year (t-1)	Increased	Increased
	6	Number of agriculture project at year (t)	Increased	Increased
	7	Urban female population density	Increased	Increased
	8	Number of energy project at year (t)	Increased	Increased
	9	Energy project budget at year (t)	Increased	Increased
	10	Health project budget at year (t-2)	Increased	Increased
Number of people wounded	1	Number of education project at year (t-1)	Increased	Increased
	2	Number of capacity building at year (t-1)	Increased	Increased
	3	Health project budget at year (t)	Increased	Increased
	4	Number of energy project at year (t-1)	Increased	Increased
	5	Water and sanitation project budget at year (t)	Increased	Increased
	6	Security project budget at year (t-1)	Increased	Decreased
	7	Number of gender project at year (t-1)	Increased	Decreased
	8	Urban female population density	Increased	Increased
	9	Number of education project at year (t-2)	Increased	Increased
	10	Number of security project at year (t-2)	Increased	Increased
Number of people hijacked	1	Environment project budget at year (t)	Increased	Decreased
	2	Energy project budget at year (t-1)	Increased	Decreased
	3	Energy project budget at year (t)	Increased	Decreased
	4	Number of energy project at year (t-1)	Increased	Decreased
	5	Water and sanitation project budget at year (t-2)	Increased	Decreased
	6	Water and sanitation project budget at year (t)	Increased	Decreased
	7	Environment project budget at year (t-1)	Increased	Decreased
	8	Energy project budget at year (t-2)	Increased	Decreased
	9	Number of emergency assistance at year (t-2)	Increased	Decreased
	10	Number of energy project at year (t)	Increased	Decreased
Total number of adverse events	1	Total number of adverse events at month (t-1)	Increased	Increased
	2	Number of agriculture project at year (t-2)	Increased	Increased
	3	Number of water and sanitation at year (t)	Increased	Increased
	4	Environment project budget at year (t-2)	Increased	Increased
	5	Health project budget at year (t-1)	Increased	Increased
	6	Urban female population density	Increased	Increased
	7	Community dev. project budget at year (t-2)	Increased	Increased
	8	Gender project budget at year (t-1)	Increased	Increased
	9	Environment project budget at year (t-1)	Increased	Increased
	10	Governance project budget at year (t-2)	Increased	Increased

Table 43: The rank of inputs and their effect on dependent variables of south western region

Output	Rank	Input values	Input	Output
Number of people killed	1	Transport project budget at year (t-2)	Increased	Increased
	2	Number of gender project at year (t-2)	Increased	Increased
	3	Transport project budget at year (t)	Increased	Increased
	4	Transport project budget at year (t-1)	Increased	Increased
	5	Number of people killed at month (t-1)	Increased	Increased
	6	Number of transport project at year (t)	Increased	Increased
	7	Number of transport project at year (t-1)	Increased	Increased
	8	Number of environment project at year (t-2)	Increased	Increased
	9	Number of capacity building at year (t-2)	Increased	Increased
	10	Number of transport project at year (t-2)	Increased	Increased
Number of people wounded	1	Number of people wounded at month (t-1)	Increased	Increased
	2	Number of commerce and industry at year (t)	Increased	Increased
	3	Urban female population density	Increased	Increased
	4	Urban male population density	Increased	Increased
	5	Number of energy project at year (t-1)	Increased	Increased
	6	Transport project budget at year (t)	Increased	Increased
	7	Transport project budget at year (t-1)	Increased	Increased
	8	Number of environment project at year (t-2)	Increased	Increased
	9	Number of energy project at year (t-2)	Increased	Decreased
	10	Number of education project at year (t-2)	Increased	Increased
Number of people hijacked	1	Number of health project at year (t-2)	Increased	Increased
	2	Number of governance project at year (t-2)	Increased	Increased
	3	Number of Community dev. project at year (t)	Increased	Increased
	4	Number of water and sanitation at year (t)	Increased	Increased
	5	Number of security project at year (t)	Increased	Increased
	6	Number of commerce and ind. at year (t-2)	Increased	Increased
	7	Number of health project at year (t-1)	Increased	Increased
	8	Number of education project at year (t-1)	Increased	Increased
	9	Number of governance project at year (t)	Increased	Decreased
	10	Governance project budget at year (t)	Increased	Decreased
Total number of adverse events	1	Total number of adverse events at month (t-1)	Increased	Increased
	2	Transport project budget at year (t-2)	Increased	Increased
	3	Number of energy project at year (t-1)	Increased	Increased
	4	Number of energy project at year (t-2)	Increased	Increased
	5	Number of Community dev. proj. at year (t-2)	Increased	Increased
	6	Number of agriculture project at year (t)	Increased	Increased
	7	Transport project budget at year (t-1)	Increased	Increased
	8	Number of transport project at year (t-1)	Increased	Increased
	9	Number of transport project at year (t-2)	Increased	Increased
	10	Number of environment project at year (t-1)	Increased	Increased

Table 44: The rank of inputs and their effect on dependent variables of western region

Output	Rank	Input values	Input	Output
Number of people killed	1	Energy project budget at year (t)	Increased	Decreased
	2	Number of environment project at year (t)	Increased	Decreased
	3	Number of water and sanitation at year (t-1)	Increased	Decreased
	4	Number of security project at year (t)	Increased	Decreased
	5	Gender project budget at year (t-1)	Increased	Decreased
	6	Water and sanitation proj. budget at year (t-2)	Increased	Decreased
	7	Number of agriculture project at year (t-1)	Increased	Decreased
	8	Number of Community dev. project at year (t)	Increased	Decreased
	9	Number of transport project at year (t-2)	Increased	Decreased
	10	Number of gender project at year (t-2)	Increased	Decreased
Number of people wounded	1	Number of people wounded at month (t-1)	Increased	Increased
	2	Number of health project at year (t)	Increased	Decreased
	3	Number of commerce and industry at year (t)	Increased	Increased
	4	Number of capacity building at year (t-2)	Increased	Increased
	5	Number of agriculture project at year (t-1)	Increased	Increased
	6	Number of Community development at year (t)	Increased	Increased
	7	Number of transport project at year (t-2)	Increased	Decreased
	8	Number of security project at year (t-2)	Increased	Increased
	9	Number of transport project at year (t-1)	Increased	Decreased
	10	Number of commerce and industry at year (t-1)	Increased	Increased
Number of people hijacked	1	Energy project budget at year (t-2)	Increased	Increased
	2	Number of commerce and industry at year (t-2)	Increased	Increased
	3	Transport project budget at year (t)	Increased	Increased
	4	Number of energy project at year (t)	Increased	Increased
	5	Community dev. project budget at year (t-1)	Increased	Increased
	6	Energy project budget at year (t-1)	Increased	Increased
	7	Number of emergency assistance at year (t)	Increased	Increased
	8	Number of capacity building project at year (t)	Increased	Increased
	9	Emergency assistance project budget at year (t)	Increased	Increased
	10	Number of gender project at year (t-1)	Increased	Increased
Total number of adverse events	1	Total number of adverse events at month (t-1)	Increased	Increased
	2	Number of commerce and industry at year (t-2)	Increased	Increased
	3	Urban male population density	Increased	Increased
	4	Urban female population density	Increased	Increased
	5	Number of agriculture project at year (t-2)	Increased	Increased
	6	Number of community dev. at year (t-2)	Increased	Increased
	7	Commerce and indust. proj. budg. at year (t-2)	Increased	Increased
	8	Number of governance project at year (t-1)	Increased	Increased
	9	Transport project budget at year (t-2)	Increased	Increased
	10	Governance project budget at year (t)	Increased	Increased

For total number of adverse events, totally eleven community development projects were listed as highly ranked independent variables in seven regions. Eight out of eleven community development projects had positive relationship, and the remaining three projects had negative relationships that belong to north western region.

The graphical illustration of the first and the second ranked variables are represented to show the increment or decrement of output values while increasing input values. As an illustration, Figures 68 and 69 provides information about the effect of the first and second ranked independent variable on number of people wounded in eastern region. It is shown that while increasing budgets of security and water and sanitation projects, number of people wounded decreases. Figures 126 through 179 in Appendix G represent the effect of top two ranked of all independent variables on dependent variables in each region.

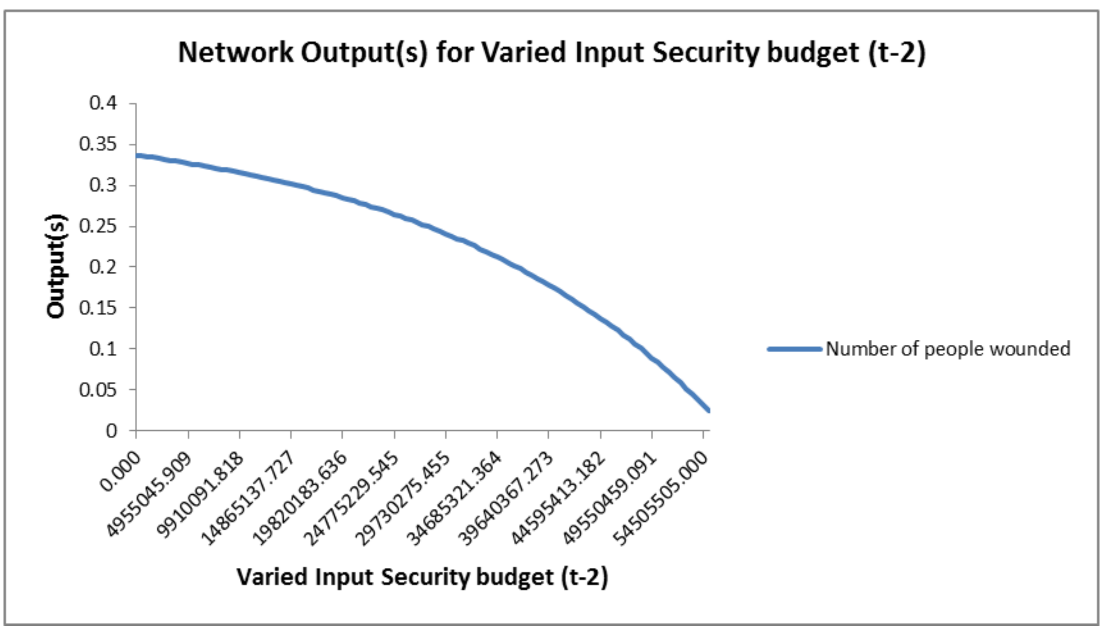


Figure 68: The effect of the first ranked independent variable on number of people wounded in Eastern region

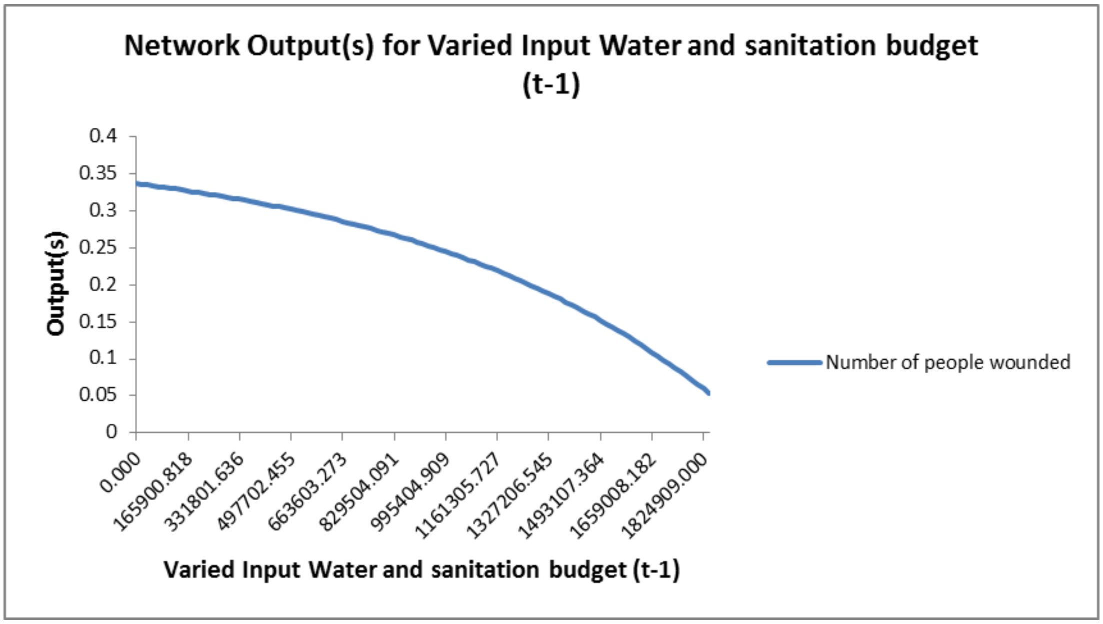


Figure 69: The effect of the second ranked independent variable on number of people wounded in Eastern region

The ranking of each independent variable on dependent variables varies based on the the region. For instance, in central region the sensitivity analysis of independent variables revealed that urban female and male population density had the highest sensitivity on number of people killed; while, urban female population density and water and sanitation aid number (t-2) had the highest sensitivity on number of people wounded; urban female population density and education aid number (t-1) had the highest sensitivity on number of people hijacked; total number of adverse events at time previous month and commerce & industry aid number (t-1) had the highest sensitivity on total number of adverse events.

For eastern region, the sensitivity analysis of independent variables revealed that transport aid number (t-2) and environment budget (t-1) had the highest sensitivity on number of people killed; while, security budget (t-2) and water and sanitation budget (t-1) had the highest sensitivity on number of people wounded; security budget (t-2) and education budget (t) had the highest sensitivity on number of people hijacked; transport aid number (t-2) and emergency assistance aid number (t-1) had the highest sensitivity on total number of adverse events.

For north eastern region, the sensitivity analysis of independent variables revealed that security budget (t) and agriculture budget (t-2) had the highest sensitivity on number of people killed; while, transport budget at year (t) and (t-1) had the highest sensitivity on number of people wounded; transport budget at year (t) and (t-1) had the highest sensitivity on number of people hijacked; total number of adverse events at time previous month and commerce & industry aid number (t-1) had the highest sensitivity on total number of adverse events.

For north western region, the sensitivity analysis of independent variables revealed that urban male population density and community development budget (t-2) had the highest sensitivity on number of people killed; while, agriculture aid number (t-2) and transport budget (t) had the highest sensitivity on number of people wounded; community development budget at year (t) and (t-1) had the highest sensitivity on number of people hijacked; community development budget at year (t) and (t-1) had the highest sensitivity on total number of adverse events.

For south eastern region, the sensitivity analysis of independent variables revealed that number of people killed at previous month and agriculture aid number (t-2) had the highest sensitivity on number of people killed; while, education aid number (t-1) and capacity building aid number (t-1) had the highest sensitivity on number of people wounded; environment budget (t) and energy budget (t-1) had the highest sensitivity on number of people hijacked; total number of adverse events at time previous month and agriculture aid number (t-2) had the highest sensitivity on total number of adverse events.

For south western region, the sensitivity analysis of independent variables revealed that transport budget (t-2) and gender aid number (t-2) had the highest sensitivity on number of people killed; while, number of people wounded at previous month and commerce and industry aid number (t) had the highest sensitivity on number of people wounded; health aid number (t-2) and governance aid number (t-2) had the highest sensitivity on number of people hijacked; total number of adverse events at time previous month and transport budget (t-2) had the highest sensitivity on total number of adverse events.

For western region, the sensitivity analysis of independent variables revealed that energy budget (t) and environment aid number (t) had the highest sensitivity on number of people killed; while, number of people wounded at previous month and health aid number (t) had the highest sensitivity on number of people wounded; energy budget (t-2) and commerce and industry aid number (t-2) had the highest sensitivity on number of people hijacked; total number of adverse events at time previous month and commerce and industry aid number (t-2) had the highest sensitivity on total number of adverse events.

Classification of top ten projects affected dependent variables is summarized based on the region and time period. Tables 45 through 48 provide information about the importance of project types for number of people killed, wounded, hijacked, and total number of adverse events in each region. This may be helpful for the allocation of projects to the regional development.

Table 45: Classification of top ten projects affected number of people killed based on region and time period

Region	Significant project types for number of people killed		
	(t-2)	**(t-1)**	**(t)**
Central	Environment	Water and sanitation Energy	Environment Security Commerce and industry
Eastern	Transport Health Emergency assistance Capacity building	Environment Transport	Capacity building Gender
North Eastern	Agriculture Community development Commerce and industry Gender	Gender	Security Environment Community development Governance
North Western	Community development Commerce and industry Water and sanitation	Transport Agriculture Gender Education Security	
South Eastern	Agriculture Commerce and industry Health	Gender Governance	Agriculture Energy
South Western	Transport Gender Environment Capacity building	Transport	Transport
Western	Water and sanitation Transport Gender	Water and sanitation Gender Agriculture	Energy Environment Security Community development

Table 46: Classification of top ten projects affected number of people wounded based on region and time period

Region	**Significant project types for number of people wounded**		
	(t-2)	**(t-1)**	**(t)**
Central	Water and sanitation Gender Capacity building Security Health	Commerce and industry Capacity building	Health
Eastern	Security Health	Water and sanitation Environment Agriculture Security Education	Transport Energy Health
North Eastern	Transport Water and sanitation Emergency assistance Gender	Transport Emergency assistance	Transport Emergency assistance
North Western	Agriculture Energy Emergency assistance	Security Water and sanitation Transport Gender	Transport
South Eastern	Education Security	Education Capacity building Energy Security Gender	Health Water and sanitation
South Western	Environment Energy Education	Energy Transport	Commerce and industry Transport
Western	Capacity building Transport Security	Agriculture Transport Commerce and industry	Health Commerce and industry Community development

Table 47: Classification of top ten projects affected number of people hijacked based on region and time period

Region	**Significant project types for number of people hijacked**		
	(t-2)	**(t-1)**	**(t)**
Central	Agriculture Water and sanitation Education Community development	Education Health	Water and sanitation Education Agriculture
Eastern	Security Education Governance		Education Gender Security
North Eastern	Capacity building Community development Transport Governance	Transport Community development Capacity building	Transport Community development
North Western	Governance Community development Health Capacity building Commerce and industry	Community development Governance	Community development Governance
South Eastern	Water and sanitation Energy Emergency assistance	Energy Environment	Environment Energy Water and sanitation
South Western	Health Governance Commerce and industry	Health Education	Community development Water and sanitation Security Governance
Western	Energy Commerce and industry	Community development Energy Gender	Transport Energy Emergency assistance Capacity building

Table 48: Classification of top ten projects affected total number of adverse events based on region and time period

Region	Significant project types for total number of adverse events		
	(t-2)	(t-1)	(t)
Central	Gender Education Transport	Commerce and industry Education	Agriculture Health
Eastern	Transport Community development Emergency assistance	Emergency assistance Environment Gender Community development	Community development Capacity building
North Eastern	Commerce and industry Community develop.	Commerce and industry Agriculture	Health Education Gender
North Western	Community development Commerce and industry Health Governance	Community development Governance	Community development Governance Education
South Eastern	Agriculture Environment Community development Governance	Health Gender Environment	Water and sanitation
South Western	Transport Energy Community development	Energy Transport Environment	Agriculture
Western	Commerce and industry Agriculture Community development Transport	Governance	Governance

Beside regional effect, the ranking of each independent variable on dependent variables varies based on the time periods. In this research, we considered the projects started at two years ago, one year ago and the same year that adverse events occurred. Number of projects occurred in these time periods is represented in Table 49. When the results were examined based on these time periods, interesting observations can be made. Based on the classification results, number of projects started at year (t-2) is significantly higher than the projects started at year (t-1) and (t). And the number of projects started at year (t-1) is higher than the projects started at year (t). Such results indicate that concluding the positive or negative effects of aid projects on the occurrence of adverse events may need long time.

Table 49: Number of projects based on time period that affect dependent variables

Region	**Number of projects starts at year (t-2)**	**Number of projects starts at year (t-1)**	**Number of projects starts at year (t)**
Central	14	9	9
Eastern	13	11	12
North Eastern	18	9	11
North Western	16	14	6
South Eastern	12	13	10
South Western	15	10	10
Western	12	10	13
TOTAL	**100**	**76**	**71**

For the purpose of allocating resources and development of regions, the results can be summarized by examining the relationship between adverse events and infrastructure development in an active war theater; emphasis was on predicting the occurrence of incidents to determine how risky the different parts of Afghanistan, and assessing the potential impact of regional infrastructure development efforts on reducing number of adverse events.

CHAPTER V: CONCLUSION

5.1. Study Contributions

This study developed three prediction models that allow: i) investigation of the relationship between adverse events and infrastructure development in an active war theater using soft computing techniques, ii) prediction of the occurrence of adverse events in different regions of Afghanistan, and iii) assessment of the potential impact of regional infrastructure development efforts on occurrence of adverse events.

5.2. Summary of Study

Based on the previous research, there is currently no study on the use of any computational methodology for representing the relationship between adverse events and infrastructure development investments in an active war theater. In this research, artificial neural networks (ANNs), fuzzy inference system (FIS), and adaptive-neuro fuzzy inference system (ANFIS) were applied to estimate the occurrence of adverse events for Afghanistan and its seven regions. ANNs, FIS, and ANFIS have been employed to relate population density and developmental or economic project type, categorized by amount of allocated funds to the number of adverse events in that region taking place in the same time period. When the model accuracy was calculated based on the mean absolute error (MAE) for each of the models, the ANN had better predictive accuracy than FIS and ANFIS models as demonstrated by experimental results. Sensitivity analysis shows that the number of adverse events in a previous month, "urban" and "rural" population density are the significant parameters for most of the regions. The ranking of project types on dependent variables varies based on the time period and the region. Based on the sensitivity analysis results, historical projects had more effect on dependent variables. According to the the results obtained, it is concluded that the ANNs, FIS, and ANFIS are useful modeling techniques to predict the number of adverse events based on historical development or economic projects data. Such modeling approaches can be considered to support decision makers who analyze historical economic data on how regional budget or funds allocation can best help reduce or minimize adverse events. In summary, these techniques were considered to examine the relationship between adverse events and infrastructure development in an active war theater. These models may be considered as general models that used Afghanistan data for validation and verification. The model has applicability for another country looking to build infrastructure while terrorist and military activities are present.

5.3 Study Limitations and Future Work

5.3.1 Data Limitations

The data represented in this research came from different sources include news and internet. These records were collected manually in Microsoft Excel files. Based on the personal communication with technical team of HSCB program management, 75% of data is correct. Some part of the data is incomplete and there is uncertainty in input data. For instance, population density data is available only for 2008. Most records are zero values; this situation increases nonlinearity in dataset. All these limitations might have affected the prediction accuracy of the models.

5.3.2 ANN Model Limitations

There are several network parameters that can affect the performance of an ANN. These parameters can be summarized as the number of hidden layer, number of neurons in a hidden layer, number of output layer units, momentum coefficient, learning algorithms, learning rate, maximum number of epochs, deciding which activation functions of the hidden and output nodes. Selection of these parameters requires high level of computational time. For further studies, some of these parameters should be optimized to reduce inconsistency and the computation time. ANNs usually need more data for better training and this provides the more accurate results in testing data. For further studies, more training data should be included to improve the ANN model performance.

5.3.3 FIS Model Limitations

In the FIS, any acceptable number of independent and dependent variables can be processed and the coreesponding rules and membership functions can be generated easily. However, it may be complicated while constructing fuzzy inference systems especially when the number of input values are high. High number of interrelation between input and output values requires too many rules and membership functions. Clustering algorithms were applied to seperate the data into clusters that each one acts as the specific part of the system behavior. Therefore, one cluster represents the one rule and corresponding membership function. Due to their computational efficiency, fuzzy c-means (FCM) and subtractive clustering algorithms have been applied to extract a set of rules and generate membership functions in this study. It must be indicated that these algorithms may not be the optimum one, and different approaches should be tried such as optimization-based methods (simulated annealing algorithm and genetic algorithms) and the best one has to be found for further studies.

5.3.4 ANFIS Model Limitations

Excessive number of inputs creates difficulty in model construction. ANFIS input selection algorithm was used to reduce complexity for ANFIS modeling section of the study. We selected this approach because of its simplicity, computational efficiency and that includes ANFIS in the implementation phases. For future analysis, other input reduction techniques such as clustering algorithms, principal component analysis, stepwise regression analysis, and linear discriminant analysis might be considered with ANFIS and the performance results can be compared to each other.

APPENDIX A: SNAPSHOT OF PARTIAL DATASET

B1(t-2)	B2(t-2)	B3(t-2)	B4(t-2)	B5(t-2)	B6(t-2)	B7(t-2)	B8(t-2)	B9(t-2)	B10(t-2)	B11(t-2)	B12(t-2)	B13(t-2)	B14(t-2)
78251.94	0	0	19578252	7709535	0	0	0	0	0	0	78251.94	0	0
469511.7	0	0	19578252	7709535	0	0	0	0	0	0	78251.94	0	0
78251.94	0	0	19578252	7709535	0	0	0	0	0	0	78251.94	0	0
469511.7	0	0	19578252	7709535	0	0	0	0	0	0	78251.94	0	0
469511.7	0	0	19578252	7709535	0	0	0	0	0	0	78251.94	0	0
0	0	0	19578252	7709535	0	0	0	0	0	0	0	0	0
469511.7	0	0	19578252	7709535	0	0	0	0	0	0	78251.94	0	0
469511.7	0	0	19578252	7709535	0	0	0	0	0	0	78251.94	0	0
156503.9	0	0	19578252	7709535	0	0	0	0	0	0	0	0	0
78251.94	0	0	78251.94	7709535	0	0	0	0	44456	0	0	0	0
156503.9	0	0	78251.94	7709535	0	0	0	0	44456	0	0	0	0
0	0	0	78251.94	7709535	0	0	0	0	44456	0	0	0	0
469511.7	0	0	78251.94	7709535	0	0	0	0	44456	0	0	0	0
234755.8	0	0	78251.94	7709535	0	0	0	0	44456	0	78251.94	0	0
0	0	0	78251.94	7709535	0	0	0	0	44456	0	0	0	0
234755.8	0	0	78251.94	7709535	0	0	0	0	44456	0	0	0	0
391259.7	0	0	78251.94	7709535	0	0	0	0	44456	0	0	0	0
0	0	0	78251.94	7709535	0	0	0	0	44456	0	0	0	0
0	0	0	78251.94	7709535	0	0	0	0	44456	0	0	0	0
0	0	0	78251.94	7709535	0	0	0	0	44456	0	0	0	0
0	0	0	78251.94	7709535	0	0	0	0	44456	0	0	0	0
0	0	0	78251.94	7709535	0	0	0	0	44456	0	0	0	0
0	0	0	78251.94	7709535	0	0	0	0	44456	0	0	0	0
0	0	0	78251.94	7709535	0	0	0	0	44456	0	0	0	0
391259.7	0	0	78251.94	7709535	0	0	0	0	44456	0	0	0	0
0	0	0	0	7709535	0	0	0	0	0	0	0	0	0
0	0	0	0	7709535	0	0	0	0	0	0	0	0	0
0	0	0	0	7709535	0	0	0	0	0	0	0	0	0

Figure 70: Partial budget info of fourteen projects at year t-2

A1(t-2)	A2(t-2)	A3(t-2)	A4(t-2)	A5(t-2)	A6(t-2)	A7(t-2)	A8(t-2)	A9(t-2)	A10(t-2)	A11(t-2)	A12(t-2)	A13(t-2)	A14(t-2)
1	0	0	1	4	0	0	0	0	4	0	1	0	0
1	0	0	1	4	0	0	0	0	3	0	1	0	0
0	0	0	1	4	0	0	0	0	3	0	0	0	0
0	0	0	1	4	0	0	0	0	3	0	0	0	0
1	0	0	1	4	0	0	0	0	3	0	0	0	0
7	0	0	0	3	0	0	0	0	3	0	1	1	0
3	0	0	0	3	0	0	0	0	3	0	0	1	0
2	0	0	0	3	0	0	0	0	3	0	1	1	0
2	0	0	0	3	0	0	0	0	3	0	0	1	0
2	0	0	0	3	0	0	0	0	3	0	0	1	0
2	0	0	0	3	0	0	0	0	3	0	0	1	0
2	0	0	0	3	0	0	0	0	3	0	0	1	0
2	0	0	0	3	0	0	0	0	3	0	0	1	0
2	0	0	0	3	0	0	0	0	3	0	0	1	0
2	0	0	0	3	0	0	0	0	3	0	0	1	0
2	0	0	0	3	0	0	0	0	3	0	0	1	0
0	0	0	1	17	0	0	0	0	3	0	0	0	0
0	0	0	1	3	0	0	0	0	3	0	0	0	0
0	0	0	1	3	0	0	0	0	3	0	0	0	0
0	0	0	1	3	0	0	0	0	3	0	0	0	0
0	0	0	1	3	0	0	0	0	3	0	0	0	0
0	0	0	1	3	0	0	0	0	3	0	0	0	0
0	0	0	1	3	0	0	0	0	3	0	0	0	0
0	0	0	1	3	0	0	0	0	3	0	0	0	0
0	0	0	1	3	0	0	0	0	3	0	0	0	0
0	0	0	1	3	0	0	0	0	3	0	0	0	0
0	0	0	1	3	0	0	0	0	3	0	0	0	0
0	0	0	1	3	0	0	0	0	3	0	0	0	0

Figure 71: Partial aid number info of fourteen projects at year t-2

B1(t-1)	B2(t-1)	B3(t-1)	B4(t-1)	B5(t-1)	B6(t-1)	B7(t-1)	B8(t-1)	B9(t-1)	B10(t-1)	B11(t-1)	B12(t-1)	B13(t-1)	B14(t-1)
507174.3	0	5380803	7061249	15081458	0	45225	0	0	709668.4	0	378251.9	0	52074.07
289251.9	0	5380803	7061249	15081458	0	45225	0	0	709668.4	0	378251.9	0	52074.07
211000	0	5380803	7061249	15081458	0	45225	0	0	709668.4	0	300000	0	52074.07
211000	0	5380803	7061249	15081458	0	45225	0	0	709668.4	0	300000	0	52074.07
289251.9	0	5380803	7061249	15081458	0	45225	0	0	709668.4	0	300000	0	52074.07
635372.8	0	5380803	4189892	62917494	0	0	0	0	2786706	0	78251.94	92867359	137300
286112.8	0	5380803	4189892	62917494	0	0	0	0	2786706	0	0	92867359	137300
199860.8	0	5380803	4189892	62917494	0	0	0	0	2786706	0	78251.94	70129939	137300
199860.8	0	5380803	4189892	62917494	0	0	0	0	2786706	0	0	70129939	137300
199860.8	0	5380803	4189892	62917494	0	0	0	0	2786706	0	0	70129939	137300
324680	0	5380803	4189892	62917494	0	0	0	0	2786706	0	0	70129939	137300
199860.8	0	5380803	4189892	62917494	0	0	0	0	2786706	0	0	70129939	137300
199860.8	0	5380803	4189892	62917494	0	0	0	0	2786706	0	0	70129939	137300
199860.8	0	5380803	4189892	62917494	0	0	0	0	2786706	0	0	70129939	137300
199860.8	0	5380803	4189892	62917494	0	0	0	0	2786706	0	0	70129939	137300
199860.8	0	5380803	4189892	62917494	0	0	0	0	2786706	0	0	70129939	137300
573850.7	1392	5380803	18468002	21050450	0	0	13620	0	1368800	334044.3	0	0	52216
543640.5	0	5380803	18450202	21050450	0	0	13620	0	1368800	260000	0	0	52216
543640.5	0	5380803	18450202	21050450	0	0	13620	0	1368800	260000	0	0	52216
543640.5	0	5380803	18450202	21050450	0	0	13620	0	1368800	260000	0	0	52216
543640.5	0	5380803	18450202	21050450	0	0	13620	0	1368800	260000	0	0	52216
543640.5	0	5380803	18450202	21050450	0	0	13620	0	1368800	260000	0	0	52216
543640.5	0	5380803	18450202	21050450	0	0	13620	0	1368800	260000	0	0	52216
543640.5	0	5380803	18450202	21050450	0	0	13620	0	1368800	260000	0	0	52216
543640.5	0	5380803	18450202	21050450	0	0	13620	0	1368800	260000	0	0	52216
543640.5	0	5380803	18450202	21050450	0	0	13620	0	1368800	591240	0	0	52216
563780.6	0	5380803	18450202	21050450	0	0	13620	0	1368800	922480	0	0	52216
543640.5	0	5380803	18450202	21050450	0	0	13620	0	1368800	260000	0	0	52216

Figure 72: Partial budget info of fourteen projects at year t-1

A1(t-1)	A2(t-1)	A3(t-1)	A4(t-1)	A5(t-1)	A6(t-1)	A7(t-1)	A8(t-1)	A9(t-1)	A10(t-1)	A11(t-1)	A12(t-1)	A13(t-1)	A14(t-1)
8	0	1	18	6	0	2	0	0	4	0	2	0	9
6	0	1	18	6	0	2	0	0	4	0	2	0	9
5	0	1	18	6	0	2	0	0	4	0	1	0	9
5	0	1	18	6	0	2	0	0	4	0	1	0	9
6	0	1	18	6	0	2	0	0	4	0	1	0	9
10	0	1	20	9	0	1	0	0	9	0	1	3	9
5	0	1	20	9	0	0	0	0	9	0	0	3	9
2	0	1	20	9	0	0	0	0	9	0	1	2	9
2	0	1	20	9	0	0	0	0	9	0	0	2	9
2	0	1	20	9	0	0	0	0	9	0	0	2	9
3	0	1	20	9	0	0	0	0	9	0	0	2	9
2	0	1	20	9	0	0	0	0	9	0	0	2	9
2	0	1	20	9	0	0	0	0	9	0	0	2	9
2	0	1	20	9	0	0	0	0	9	0	0	2	9
2	0	1	20	9	0	0	0	0	9	0	0	2	9
2	0	1	20	9	0	0	0	0	9	0	0	2	9
7	1	1	35	32	0	0	1	0	8	2	0	0	14
6	0	1	34	18	0	0	1	0	8	1	0	0	14
6	0	1	34	18	0	0	1	0	8	1	0	0	14
6	0	1	34	18	0	0	1	0	8	1	0	0	14
6	0	1	34	18	0	0	1	0	8	1	0	0	14
6	0	1	34	18	0	0	1	0	8	1	0	0	14
6	0	1	34	34	0	0	1	0	8	1	0	0	14
6	0	1	34	18	0	0	1	0	8	1	0	0	14
6	0	1	34	18	0	0	1	0	8	1	0	0	14
6	0	1	34	18	0	0	1	0	8	2	0	0	14
7	0	1	34	18	0	0	1	0	8	3	0	0	14
6	0	1	34	18	0	0	1	0	8	1	0	0	14

Figure 73: Partial aid number info of fourteen projects at year t-1

B1(t)	B2(t)	B3(t)	B4(t)	B5(t)	B6(t)	B7(t)	B8(t)	B9(t)	B10(t)	B11(t)	B12(t)	B13(t)	B14(t)
346174.3	0	10193803	119988	7714356	0	0	0	0	14896383	212218.3	67362984	0	121549.4
128251.9	0	10193803	119988	7714356	0	0	0	0	14485111	0	67362984	0	0
50000	0	10198106	119988	7714356	0	0	0	0	14239521	0	67284732	0	0
50000	0	10193803	119988	7714356	0	0	0	0	14239521	0	67284732	0	0
128251.9	0	10193803	119988	7714356	0	0	0	0	14239521	0	67284732	0	0
860434.8	0	10193803	143988	18280433	0	0	0	0	14239521	213545.6	35740789	22984608	17520
511112.8	0	10193803	143988	18280433	0	0	0	0	14455815	213545.6	35662537	22737420	73000
424860.8	0	10193803	143988	18280433	0	0	0	0	14239521	213545.6	35740789	0	0
424860.8	0	10193803	143988	18280433	0	0	0	0	14239521	213545.6	35662537	0	0
424860.8	0	10198106	143988	18280433	0	0	0	0	14239521	213545.6	35662537	0	0
549680	0	10193803	143988	18280433	0	0	0	0	14239521	213545.6	35662537	0	0
424860.8	0	10193803	143988	18280433	0	0	0	0	14239521	213545.6	35662537	0	0
424860.8	0	10193803	143988	18280433	0	0	0	0	14239521	213545.6	35662537	0	0
424860.8	0	10193803	143988	18280433	0	0	0	0	14239521	213545.6	35662537	0	0
424860.8	0	10193803	143988	18280433	0	0	0	0	14239521	213545.6	35662537	0	0
424860.8	0	10193803	143988	18280433	0	0	0	0	14239521	213545.6	35662537	0	0
354959.7	1392	10193803	4090788	6042233	0	0	0	4000	14924040	874135.7	60000	0	15000
324749.5	0	10193803	4072988	6042233	0	0	0	0	14672864	229545.6	60000	0	0
324749.5	0	10193803	4072988	6042233	0	0	0	0	14672864	229545.6	60000	0	0
324749.5	0	10193803	4072988	6042233	0	0	0	0	14672864	229545.6	60000	0	0
324749.5	0	10193803	4072988	6042233	0	0	0	0	14672864	229545.6	60000	0	0
324749.5	0	10193803	4072988	6042233	0	0	0	0	14672864	229545.6	60000	0	0
324749.5	0	10193803	4072988	6042233	0	0	0	0	14672864	335626.2	60000	0	0
324749.5	0	10193803	4072988	6042233	0	0	0	0	14672864	229545.6	60000	0	0
324749.5	0	10193803	4072988	6042233	0	0	0	0	14672864	229545.6	60000	0	0
324749.5	0	10198106	4072988	6042233	0	0	0	0	14672864	560785.6	60000	0	0
344889.6	0	10193803	4072988	6042233	0	0	0	0	14672864	995171.2	60000	0	0
324749.5	0	10193803	4072988	6042233	0	0	0	0	14672864	229545.6	60000	0	0

Figure 74: Partial budget info of fourteen projects at year t

A1(t)	A2(t)	A3(t)	A4(t)	A5(t)	A6(t)	A7(t)	A8(t)	A9(t)	A10(t)	A11(t)	A12(t)	A13(t)	A14(t)
1	0	1	1	44	0	0	0	0	5	2	0	0	0
4	1	1	2	32	0	0	0	0	5	2	1	0	2
1	0	1	1	4	0	0	0	0	5	2	0	0	0
1	0	1	1	4	0	0	0	0	5	2	0	0	0
25	1	1	5	7	0	0	0	0	4	2	0	0	0
26	0	1	4	7	0	0	0	0	4	2	0	0	0
23	0	1	4	8	0	0	0	0	4	2	0	0	0
23	0	1	4	8	0	0	0	0	4	2	0	0	0
24	0	1	4	10	0	0	0	0	4	2	0	0	0
23	0	1	4	7	0	0	0	0	4	2	0	0	0
23	0	1	4	7	0	0	0	0	4	2	0	0	0
23	0	1	4	7	0	0	0	0	4	2	0	0	0
24	0	1	4	17	0	0	0	0	4	2	0	0	0
23	0	1	4	7	0	0	0	0	4	2	0	0	0
23	0	1	4	4	0	0	0	0	4	2	0	0	0
23	0	1	4	4	0	0	0	0	4	2	0	0	0
23	1	1	5	7	0	0	0	0	4	2	0	0	0
23	0	1	4	4	0	0	0	0	4	2	0	0	0
23	0	1	4	7	0	0	0	0	4	2	0	0	0
23	0	1	4	7	0	0	0	0	4	2	0	0	0
26	0	1	4	7	0	0	0	0	4	2	0	0	0
25	0	1	4	7	0	0	0	0	4	2	0	0	0
26	0	1	4	4	0	0	0	0	4	2	0	0	0
24	0	1	4	7	0	0	0	0	4	2	0	0	0
25	0	1	4	8	0	0	0	0	4	2	0	0	0

Figure 75: Partial aid number info of fourteen projects at year t

Urban Male Population Density	Urban Female Population Density	Rural Male Population Density	Rural Female Population Density
0.905496097	0.987813924	16.87515453	16.21661192
0	0	33.570369	33.15334578
2.939614499	2.784897946	36.46153422	34.65650778
13.74394627	13.08947264	33.63994468	32.20010269
17.40632516	15.78713212	65.9821163	63.55332674
0	0	32.30878751	30.0191884
7.704415364	7.455885836	69.33973827	66.60591347
0	0	122.8867768	119.4251775
0	0	52.7845947	51.00133137
0	0	20.67891971	19.70959535
0	0	59.48069684	59.48069684
0	0	9.75650511	9.243004841
107.3264707	101.4276112	125.1869063	121.4181905
9.35968096	8.936985691	55.4334653	53.38037399
4.02355958	3.829653094	11.44048266	11.10114631
0	0	27.40229716	26.43515726
0	0	49.65308398	48.5090037
16.21417318	15.32328455	49.26614159	48.55343068
1.828223917	1.584460728	45.70559792	44.60866357
8.114942528	8.114942528	22.41269841	21.38222952
0	0	19.79030695	18.47095316
0	0	10.20133897	9.995251313
0	0	19.6137267	18.44275794
0	0	8.946296435	8.242189771

Figure 76: Partial urban and rural population density info for male and female

Number of people killed(t-1)	Number of people wounded(t-1)	Number of people hijacked(t-1)	Number of adverse events (t-1)
4	0	0	1
0	2	0	1
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
2	3	0	3
12	5	11	2
0	0	0	0
1	0	0	2
0	0	0	0
0	0	0	0
0	0	0	0
18	6	0	4
0	0	0	0
0	0	0	0
52	11	0	7
0	0	0	1
0	0	0	0
56	87	0	12
0	0	0	0
0	0	0	0
0	0	0	0
5	0	0	1

Figure 77: Partial dataset info of number of people killed, wounded, hijacked and total number of adverse events at month t-1

Number of people killed	Number of people wounded	Number of people hijacked	Number of adverse events
3	7	0	6
0	0	0	0
1	7	0	1
0	0	0	0
0	0	0	0
0	0	0	0
2	0	0	1
0	0	0	0
0	0	0	0
1	3	0	1
0	0	0	0
0	0	0	0
9	20	0	7
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
39	43	0	3
7	9	0	2
0	0	0	0
0	0	0	0
4	11	0	4
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

Figure 78: Partial dataset info of output values

APPENDIX B: CORRELATION RESULTS

Table 50: Correlation of input values with number of people killed

Inputs	p-value	Inputs	p-value
*B(t-2)Agriculture	0.00217	B(t-1)Agriculture	0.98636569
*B(t-2)Capacity building	5.30E-38	*B(t-1)Capacity building	9.99E-24
*B(t-2)Commerce and industry	2.51E-42	*B(t-1)Commerce and industry	9.34E-12
*B(t-2)Community development	0.014461	B(t-1)Community development	0.58765133
B(t-2)Education	0.396018	*B(t-1)Education	1.58E-12
*B(t-2)Emergency assistance	2.62E-07	*B(t-1)Emergency assistance	0.04600058
*B(t-2)Energy	1.77E-23	*B(t-1)Energy	2.26E-15
*B(t-2)Environment	1.64E-18	*B(t-1)Environment	6.22E-15
*B(t-2)Gender	7.48E-08	B(t-1)Gender	0.83756001
*B(t-2)Governance	6.90E-25	*B(t-1)Governance	0.0004086
*B(t-2)Health	2.65E-14	*B(t-1)Health	8.67E-05
B(t-2)Security	0.082023	B(t-1)Security	0.25323225
*B(t-2)Transport	0.001129	B(t-1)Transport	0.39413411
*B(t-2)Water and sanitation	2.06E-19	*B(t-1)Water and sanitation	3.52E-09
*A(t-2)Agriculture	5.76E-47	*A(t-1)Agriculture	1.33E-27
*A(t-2)Capacity building	4.75E-46	*A(t-1)Capacity building	1.53E-09
*A(t-2)Commerce and industry	3.55E-115	*A(t-1)Commerce and industry	1.14E-110
*A(t-2)Community development	2.36E-74	*A(t-1)Community development	8.82E-24
*A(t-2)Education	1.63E-57	*A(t-1)Education	2.49E-28
*A(t-2)Emergency assistance	0.000118	A(t-1)Emergency assistance	0.07296464
*A(t-2)Energy	7.33E-17	*A(t-1)Energy	7.25E-17
*A(t-2)Environment	6.47E-17	*A(t-1)Environment	2.34E-10
*A(t-2)Gender	1.43E-13	*A(t-1)Gender	0.02122641
*A(t-2)Governance	6.58E-31	*A(t-1)Governance	0.00141263
*A(t-2)Health	5.84E-47	*A(t-1)Health	1.89E-20
*A(t-2)Security	1.88E-08	A(t-1)Security	0.63520863
*A(t-2)Transport	1.84E-30	*A(t-1)Transport	8.13E-15
*A(t-2)Water and sanitation	1.38E-14	*A(t-1)Water and sanitation	1.12E-06

*Statistically significant $p < 0.05$ (Highlighted in yellow)

B(t-2): Budget at year t-2
B(t-1): Budget at year t-1
B(t): Budget at year t

A(t-2): Aid Number at year t-2
A(t-1): Aid number at year t-1
A(t): Aid Number at year t

Continue from previous table

Inputs	p-value	Inputs	p-value
*B(t)Agriculture	0.0028131	*Urban male population density	2.16E-47
*B(t)Capacity building	2.24E-07	*Urban female population density	2.44E-46
*B(t)Commerce and industry	2.30E-10	*Rural male population density	0.0032882
B(t)Community development	0.1288749	*Rural female population density	0.0033364
*B(t)Education	7.36E-11	*Number of people killed at month t-1	0
B(t)Emergency assistance	0.3779789		
B(t)Energy	0.0710213		
*B(t)Environment	1.18E-07		
B(t)Gender	0.7910687		
*B(t)Governance	0.0367349		
*B(t)Health	0.0069698		
B(t)Security	0.0873281		
*B(t)Transport	0.0027756		
*B(t)Water and sanitation	0.0013408		
*A(t)Agriculture	5.04E-15		
*A(t)Capacity building	0.0001304		
*A(t)Commerce and industry	4.50E-91		
*A(t)Community development	0.0018966		
*A(t)Education	5.41E-10		
A(t)Emergency assistance	0.1926751		
*A(t)Energy	1.77E-12		
*A(t)Environment	0.0033038		
A(t)Gender	0.0817363		
*A(t)Governance	4.84E-08		
A(t)Health	0.0940321		
*A(t)Security	0.0001511		
A(t)Transport	0.5502052		
A(t)Water and sanitation	0.6922973		

Table 51: Correlation of input values with number of people wounded

Inputs	p-value	Inputs	p-value
B(t-2)Agriculture	0.30313	B(t-1)Agriculture	0.13432966
*B(t-2)Capacity building	7.91E-39	*B(t-1)Capacity building	2.92E-36
*B(t-2)Commerce and industry	2.84E-36	*B(t-1)Commerce and industry	2.55E-18
B(t-2)Community development	0.102209	B(t-1)Community development	0.56705752
B(t-2)Education	0.921775	*B(t-1)Education	2.63E-05
*B(t-2)Emergency assistance	1.17E-06	*B(t-1)Emergency assistance	0.00592851
*B(t-2)Energy	5.11E-12	*B(t-1)Energy	1.82E-07
*B(t-2)Environment	1.29E-19	*B(t-1)Environment	3.57E-13
*B(t-2)Gender	3.42E-07	B(t-1)Gender	0.6983757
*B(t-2)Governance	2.07E-16	*B(t-1)Governance	6.49E-07
*B(t-2)Health	1.18E-32	*B(t-1)Health	2.84E-19
*B(t-2)Security	0.005156	B(t-1)Security	0.85338953
*B(t-2)Transport	0.006179	B(t-1)Transport	0.27791877
*B(t-2)Water and sanitation	1.62E-21	*B(t-1)Water and sanitation	2.06E-13
*A(t-2)Agriculture	1.33E-13	*A(t-1)Agriculture	5.34E-06
*A(t-2)Capacity building	1.49E-44	*A(t-1)Capacity building	5.50E-14
*A(t-2)Commerce and industry	7.28E-110	*A(t-1)Commerce and industry	6.19E-148
*A(t-2)Community development	1.65E-66	*A(t-1)Community development	9.05E-16
*A(t-2)Education	1.16E-72	*A(t-1)Education	3.06E-50
*A(t-2)Emergency assistance	0.000729	A(t-1)Emergency assistance	0.17773953
*A(t-2)Energy	1.50E-20	*A(t-1)Energy	1.43E-13
*A(t-2)Environment	1.13E-17	*A(t-1)Environment	2.25E-17
*A(t-2)Gender	3.14E-17	*A(t-1)Gender	0.00042909
*A(t-2)Governance	1.22E-17	*A(t-1)Governance	0.00025763
*A(t-2)Health	3.54E-77	*A(t-1)Health	2.36E-28
*A(t-2)Security	7.60E-16	A(t-1)Security	0.5834309
*A(t-2)Transport	3.05E-24	*A(t-1)Transport	1.04E-11
*A(t-2)Water and sanitation	3.48E-17	*A(t-1)Water and sanitation	9.06E-11

Continue from previous table

Inputs	p-value	Inputs	p-value
*B(t)Agriculture	0.0038816	*Urban male population density	5.40E-140
*B(t)Capacity building	7.03E-10	*Urban female population density	7.08E-137
*B(t)Commerce and industry	0.0009804	Rural male population density	0.5619033
B(t)Community development	0.1791333	Rural female population density	0.5564615
*B(t)Education	8.49E-05	*Number of people wounded at month t-1	0
B(t)Emergency assistance	0.5602413		
B(t)Energy	0.2427253		
*B(t)Environment	1.66E-10		
B(t)Gender	0.8546707		
B(t)Governance	0.2765456		
*B(t)Health	1.31E-08		
B(t)Security	0.1888886		
*B(t)Transport	0.0113855		
*B(t)Water and sanitation	2.83E-05		
*A(t)Agriculture	0.0006073		
*A(t)Capacity building	0.0028298		
*A(t)Commerce and industry	2.27E-93		
*A(t)Community development	0.0241196		
*A(t)Education	1.71E-30		
*A(t)Emergency assistance	0.0228618		
*A(t)Energy	4.23E-10		
*A(t)Environment	0.0002639		
A(t)Gender	0.6876173		
*A(t)Governance	8.39E-05		
*A(t)Health	0.0004237		
*A(t)Security	0.0022418		
A(t)Transport	0.7697209		
A(t)Water and sanitation	0.6470951		

Table 52: Correlation of input values with number of people hijacked

Inputs	p-value	Inputs	p-value
B(t-2)Agriculture	0.643752	B(t-1)Agriculture	0.60198752
*B(t-2)Capacity building	0.000226	*B(t-1)Capacity building	0.00083905
*B(t-2)Commerce and industry	0.00047	B(t-1)Commerce and industry	0.51009025
B(t-2)Community development	0.379363	B(t-1)Community development	0.59556832
*B(t-2)Education	0.000359	*B(t-1)Education	8.98E-05
B(t-2)Emergency assistance	0.073075	*B(t-1)Emergency assistance	0.00025563
B(t-2)Energy	0.397353	B(t-1)Energy	0.05381503
B(t-2)Environment	0.248213	B(t-1)Environment	0.12306664
B(t-2)Gender	0.051091	B(t-1)Gender	0.55331493
B(t-2)Governance	0.474917	B(t-1)Governance	0.0850959
B(t-2)Health	0.325837	B(t-1)Health	0.89826822
B(t-2)Security	0.48524	B(t-1)Security	0.73549347
B(t-2)Transport	0.288738	B(t-1)Transport	0.50226996
B(t-2)Water and sanitation	0.261291	*B(t-1)Water and sanitation	0.00039225
A(t-2)Agriculture	0.104482	A(t-1)Agriculture	0.98382991
*A(t-2)Capacity building	0.000729	*A(t-1)Capacity building	3.96E-06
*A(t-2)Commerce and industry	0.001578	*A(t-1)Commerce and industry	0.0219327
*A(t-2)Community development	1.42E-09	*A(t-1)Community development	0.00012529
*A(t-2)Education	1.93E-07	*A(t-1)Education	0.0313894
*A(t-2)Emergency assistance	0.019381	A(t-1)Emergency assistance	0.15442464
*A(t-2)Energy	0.049136	A(t-1)Energy	0.30415108
A(t-2)Environment	0.55134	A(t-1)Environment	0.82424651
*A(t-2)Gender	0.003974	*A(t-1)Gender	5.20E-07
*A(t-2)Governance	0.000137	A(t-1)Governance	0.65045027
*A(t-2)Health	0.001408	A(t-1)Health	0.21023519
A(t-2)Security	0.373322	A(t-1)Security	0.48550451
*A(t-2)Transport	0.026562	A(t-1)Transport	0.44964739
A(t-2)Water and sanitation	0.329424	A(t-1)Water and sanitation	0.10877843

Continue from previous table

Inputs	p-value	Inputs	p-value
B(t)Agriculture	0.1497569	Urban male population density	0.3453981
B(t)Capacity building	0.470627	Urban female population density	0.3521663
*B(t)Commerce and industry	1.69E-06	*Rural male population density	0.0345618
B(t)Community development	0.444499	*Rural female population density	0.0364376
*B(t)Education	0.0010874	*Number of people hijacked at month t-1	1.12E-15
B(t)Emergency assistance	0.6124203		
B(t)Energy	0.9322106		
B(t)Environment	0.4710196		
B(t)Gender	0.8969883		
*B(t)Governance	0.00062		
B(t)Health	0.1377654		
B(t)Security	0.5827645		
B(t)Transport	0.97797		
B(t)Water and sanitation	0.6504066		
A(t)Agriculture	0.9651101		
A(t)Capacity building	0.9492033		
A(t)Commerce and industry	0.4423603		
A(t)Community development	0.1010668		
A(t)Education	0.5134196		
A(t)Emergency assistance	0.4087907		
A(t)Energy	0.5158351		
A(t)Environment	0.5472066		
A(t)Gender	0.8191424		
*A(t)Governance	0.0017175		
*A(t)Health	0.0066322		
*A(t)Security	0.0383405		
A(t)Transport	0.2404912		
A(t)Water and sanitation	0.5516534		

Table 53: Correlation of input values with total number of adverse events

Inputs	p-value	Inputs	p-value
B(t-2)Agriculture	0.144852	B(t-1)Agriculture	0.85501768
*B(t-2)Capacity building	3.22E-45	*B(t-1)Capacity building	1.56E-34
*B(t-2)Commerce and industry	3.92E-66	*B(t-1)Commerce and industry	5.24E-20
*B(t-2)Community development	1.81E-07	B(t-1)Community development	0.80723573
*B(t-2)Education	8.79E-07	*B(t-1)Education	7.00E-34
*B(t-2)Emergency assistance	5.54E-05	*B(t-1)Emergency assistance	0.00814255
*B(t-2)Energy	5.90E-19	*B(t-1)Energy	7.18E-23
*B(t-2)Environment	1.42E-31	*B(t-1)Environment	1.08E-29
*B(t-2)Gender	1.56E-05	B(t-1)Gender	0.81203848
*B(t-2)Governance	2.43E-21	*B(t-1)Governance	0.00156934
*B(t-2)Health	1.49E-19	*B(t-1)Health	6.29E-06
*B(t-2)Security	0.015505	B(t-1)Security	0.53090178
*B(t-2)Transport	1.11E-10	B(t-1)Transport	0.86742371
*B(t-2)Water and sanitation	5.51E-21	*B(t-1)Water and sanitation	4.62E-21
*A(t-2)Agriculture	5.82E-51	*A(t-1)Agriculture	1.84E-32
*A(t-2)Capacity building	1.93E-102	*A(t-1)Capacity building	2.80E-13
*A(t-2)Commerce and industry	5.08E-145	*A(t-1)Commerce and industry	1.16E-177
*A(t-2)Community development	1.11E-173	*A(t-1)Community development	2.82E-22
*A(t-2)Education	1.66E-217	*A(t-1)Education	1.32E-129
*A(t-2)Emergency assistance	1.42E-08	*A(t-1)Emergency assistance	2.58E-05
*A(t-2)Energy	3.87E-29	*A(t-1)Energy	8.46E-27
*A(t-2)Environment	4.98E-13	*A(t-1)Environment	1.35E-15
*A(t-2)Gender	1.19E-50	*A(t-1)Gender	0.00043099
*A(t-2)Governance	2.63E-42	*A(t-1)Governance	0.00860152
*A(t-2)Health	3.60E-77	*A(t-1)Health	4.95E-30
*A(t-2)Security	1.17E-11	A(t-1)Security	0.2443101
*A(t-2)Transport	8.29E-53	*A(t-1)Transport	1.04E-26
*A(t-2)Water and sanitation	8.13E-18	*A(t-1)Water and sanitation	1.78E-12

Continue from previous table

Inputs	p-value	Inputs	p-value
*B(t)Agriculture	5.76E-05	*Urban male population density	1.91E-84
*B(t)Capacity building	8.76E-12	*Urban female population density	4.29E-83
*B(t)Commerce and industry	9.00E-35	*Rural male population density	0.0331336
*B(t)Community development	0.0084178	*Rural female population density	0.0390657
*B(t)Education	8.97E-31	*Total number of adverse events at month t-1	0
B(t)Emergency assistance	0.5477641		
B(t)Energy	0.0590609		
*B(t)Environment	2.59E-21		
B(t)Gender	0.7613774		
*B(t)Governance	3.63E-06		
B(t)Health	0.5767217		
*B(t)Security	0.030796		
*B(t)Transport	0.0010124		
*B(t)Water and sanitation	3.74E-08		
*A(t)Agriculture	2.82E-14		
*A(t)Capacity building	0.002026		
*A(t)Commerce and industry	3.69E-87		
A(t)Community development	0.4709385		
*A(t)Education	6.59E-73		
*A(t)Emergency assistance	0.0328107		
*A(t)Energy	8.90E-16		
*A(t)Environment	2.24E-07		
A(t)Gender	0.9562138		
*A(t)Governance	3.00E-13		
A(t)Health	0.0503959		
*A(t)Security	7.26E-10		
A(t)Transport	0.1746755		
A(t)Water and sanitation	0.6755342		

APPENDIX C: MATLAB CODE FOR EACH METHODOLOGY

Code for ANN:

```
%ARTIFICIAL NEURAL NETWORK

%Loading training input and output data
P=xlsread('TrainingInputs.xlsx');
T=xlsread('TrainingOutput.xlsx');

%Loading testing input and data
a=xlsread('TestingInputs.xlsx');
s=xlsread('TestingOutput.xlsx');

%Normalizing data
[pn,ps] = mapminmax(P');
[tn,ts] = mapminmax(T');
[an,as] = mapminmax(a');
[sn,ss] = mapminmax(s');

%looping through the patterns, selected randomly
for i=1:50

%This script sets up the seed model. The aim is to save the random seed
%so that all simulations can be replicated.
RandStream.setDefaultStream( RandStream('mt19937ar','Seed',1234) );

%Creating feed-forward network by using levenberg-marquardt algorithm
%and log-sigmoid and hyperbolic tangent sigmoid transfer functions
net = newff(pn,tn,[i], {'logsig','tansig'},'trainlm');

%user specified training parameters
net.trainParam.epochs=1000; %Max number of epochs to train
net.trainParam.lr=0.3; %learning rate
net.trainParam.mc=0.6; %momentum coefficient
net.trainParam.goal = 0; %(stop training if the error goal hits 0)


%Training the network
net=train (net,pn,tn);

%Simulating the network
y=sim(net,an);

%transform tested data to its original form
anew = mapminmax('reverse',y',ss);
```

```
 %Evaluating prediction performance (Mean absolute error)
e=s(:)-anew(:);
perf(i)=mae(e);

%Calculating percentage of error values less than one
z=abs(e);
total=sum(z<=1);
percentage(i)=total/testing_row_number*100;

%Writing performance results
xlswrite('performance.xls',[perf'],'Sheet1');
xlswrite('performance.xls',[percentage'],'Sheet2');
end
```

Code for FIS:

```
%FUZZY CLUSTERING-FUZZY INFERENCE SYSTEM

%Loading training input and output data
P=xlsread('TrainingInputs.xlsx');
T=xlsread('TrainingOutput.xlsx');

%looping through the number of clusters (50 is selected randomly as a
%maximum cluster number)
for i=1:50

%This script sets up the seed model. The aim is to save the random seed
%so that all simulations can be replicated.
RandStream.setDefaultStream( RandStream('mt19937ar','Seed',1234) );

%generating a fuzzy inference system using fuzzy c-means (FCM) clustering
%by extracting a set of rules that models the data behavior.
fismat=genfis3(P,T,'mamdani',i);

%Loading testing input and output data
Testinputs=xlsread('testinginputs.xlsx');
Testout=xlsread('testingoutput.xlsx');

%performing fuzzy inference calculation using testing data
chkfuzout=evalfis(Testinputs,fismat);
```

```
%Evaluating prediction performance (Mean absolute error)
e=Testout(:)-chkfuzout(:);
perf(i)=mae(e);

%Calculating percentage of error values less than one
z=abs(e);
total=sum(z<=1);
percentage(i)=total/testing_row_number*100;

%Writing FIS performance results
xlswrite('FCMperformance.xls',[perf'],'Sheet1');
xlswrite('FCMperformance.xls',[percentage'],'Sheet2');
end
```

<u>Code for ANFIS:</u>

```
%ADAPTIVE NEURO-FUZZY INFERENCE SYSTEM (ANFIS)
------------------------------------------------------------------------
------------------------------------------------------------------------
%FIRST PHASE (Input Selection)

%Loading training input and output data
filename = 'TrainingInputs.xlsx';
num = xlsread(filename);
a = 'TrainingOutput.xlsx';
out = xlsread(a);

%Loading testing input and output data
filename_2 = 'TestingInputs.xlsx';
num_test = xlsread(filename_2);
b = 'TestingOutput.xlsx';
out_test = xlsread(b);

%preparing training data
trnData = [num out];

%preparing testing data
testData = [num_test out_test];

%Set of input names
input_name = char(Inputname1,inputname2,inputname3,...)
```

```
 %selecting the set of inputs that most influence the output
exhsrch(1, trnData, testData, input_name);

------------------------------------------------------------------------
------------------------------------------------------------------------
%SECOND PHASE (using selected inputs in Phase 1 to generate the final
%model)

for i=1:50 %Max number of epochs to train(50 is selected randomly)
   for j=2:6 %Number of membership functions starts from two to six

%This script sets up the seed model. The aim is to save the random seed
%so that all simulations can be replicated.
RandStream.setDefaultStream( RandStream('mt19937ar','Seed',1234) );

%Number of membership functions
numMFs = j;

%Assigning membership function type
mfType = 'trimf';

%Number of epochs
epoch_n = i;

%The genfis1 function generates a initial FIS from the training data
in_fis = genfis1(trnData,numMFs,mfType);

%initial FIS is finetuned by ANFIS to generate the final model
out_fis = anfis(trnData,in_fis,i);

%Loading testing input data
[data,txt,row]=xlsread('TestingInputs.xlsx');

%performing ANFIS calculation using testing data
predicted=evalfis([data(:,1:2)],out_fis);

%Loading testing output data
s=xlsread('TestingOutput.xlsx');

%Evaluating prediction performance (Mean absolute error)
e=s(:)-predicted(:);
perf(i)=mae(e);

%Calculating percentage of error values less than one
```

```
z=abs(e);
total=sum(z<=1);
percentage(i)=total/testing_row_number*100;

%Writing ANFIS performance results
xlswrite('performance.xls',[perf'],'Sheet1');
xlswrite('performance.xls',[percentage'],'Sheet2');
end
```

APPENDIX D: MAP REPRESENTATION OF MONTHLY PREDICTED AND OBSERVED VALUES FOR ENTIRE AFGHANISTAN

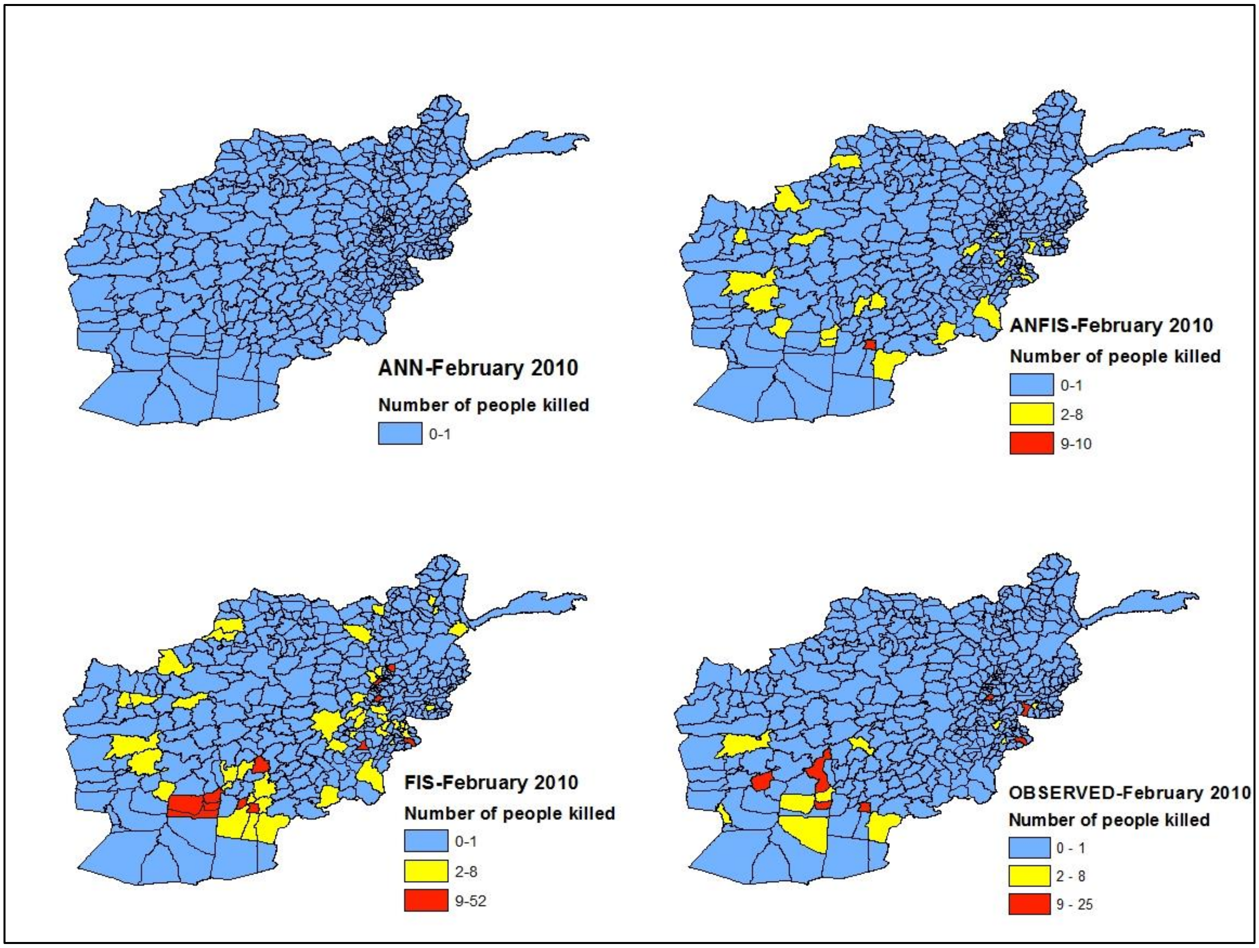


Figure 79: Predicted and observed values of number of people killed for each district in February 2010

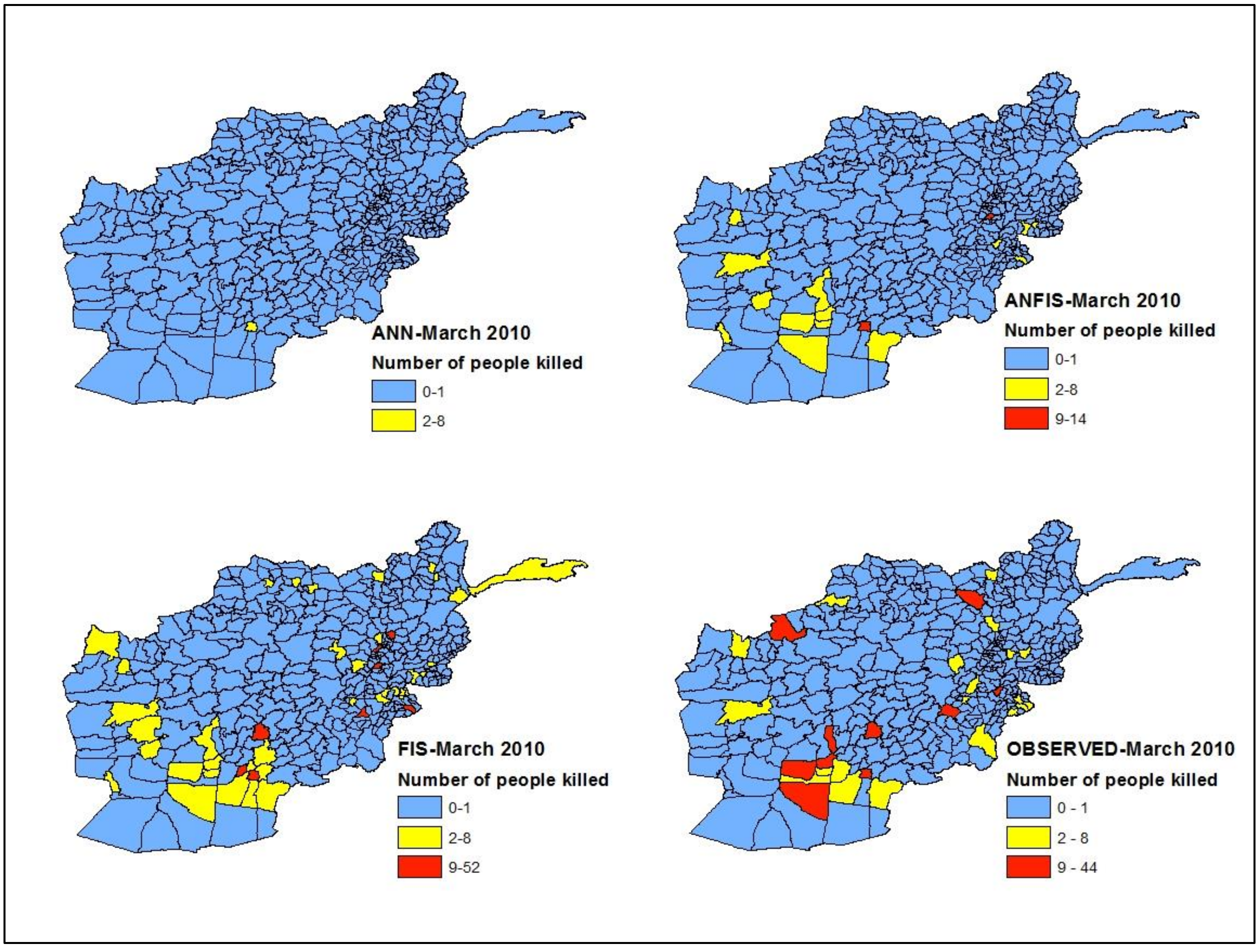


Figure 80: Predicted and observed values of number of people killed for each district in March 2010

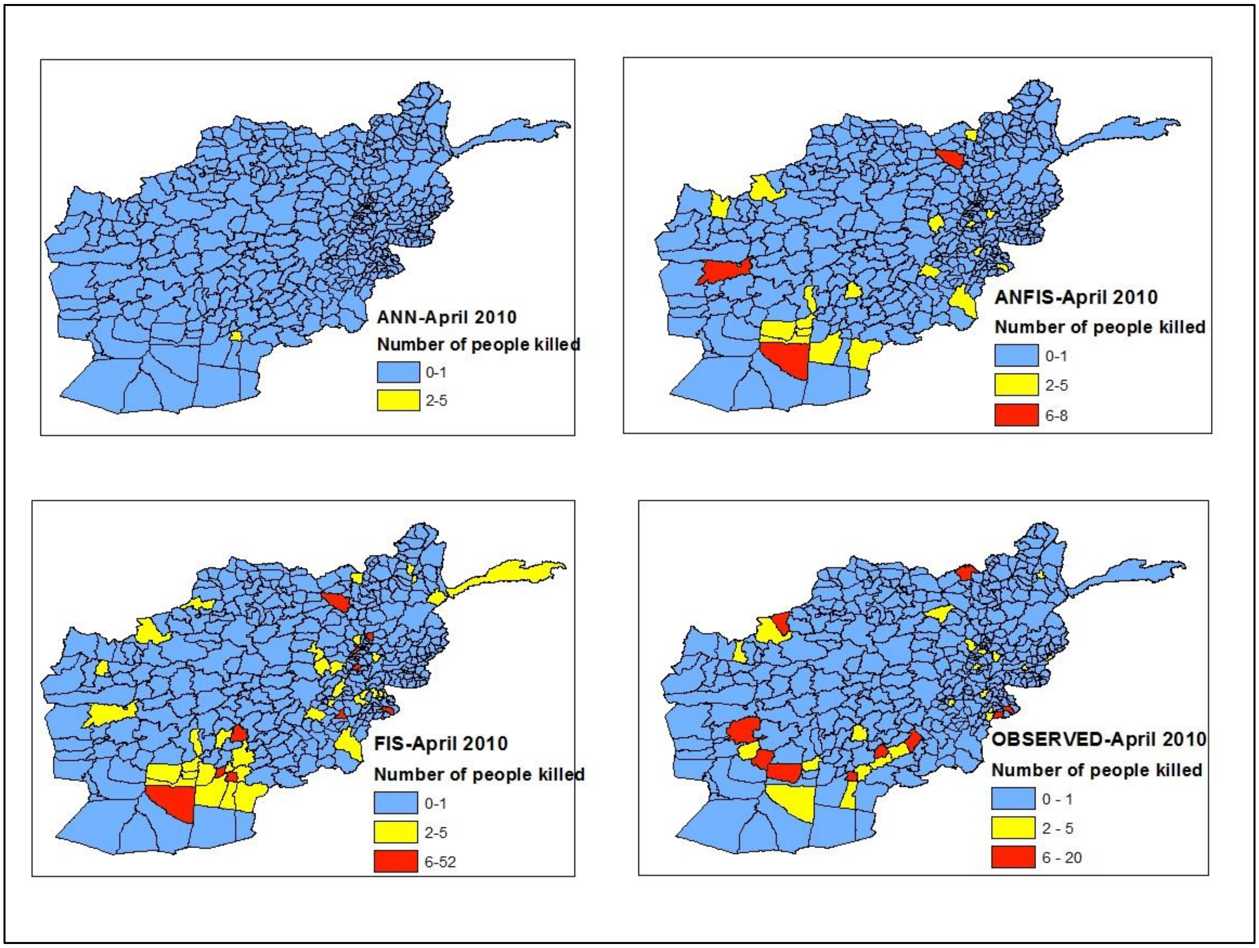


Figure 81: Predicted and observed values of number of people killed for each district in April 2010

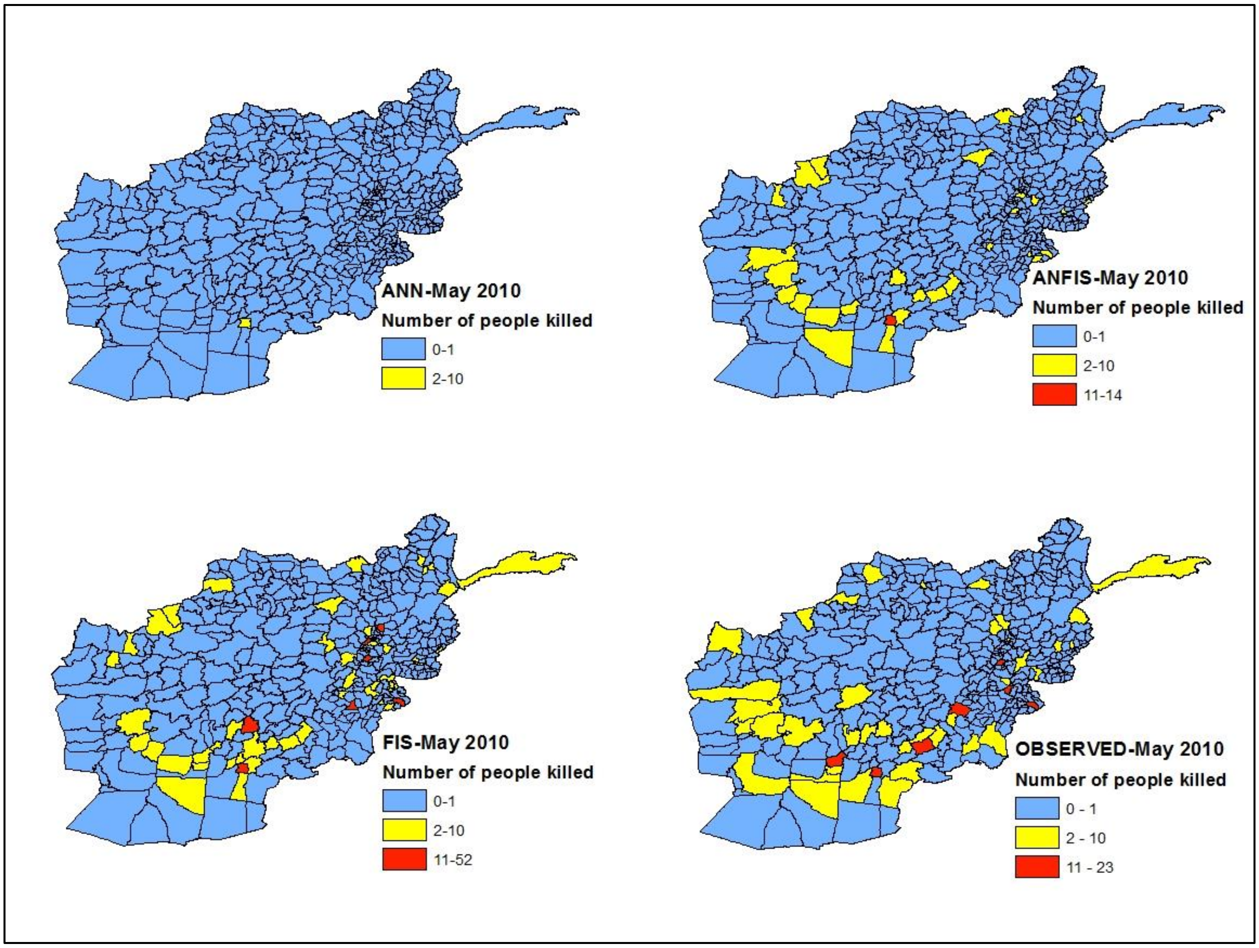


Figure 82: Predicted and observed values of number of people killed for each district in May 2010

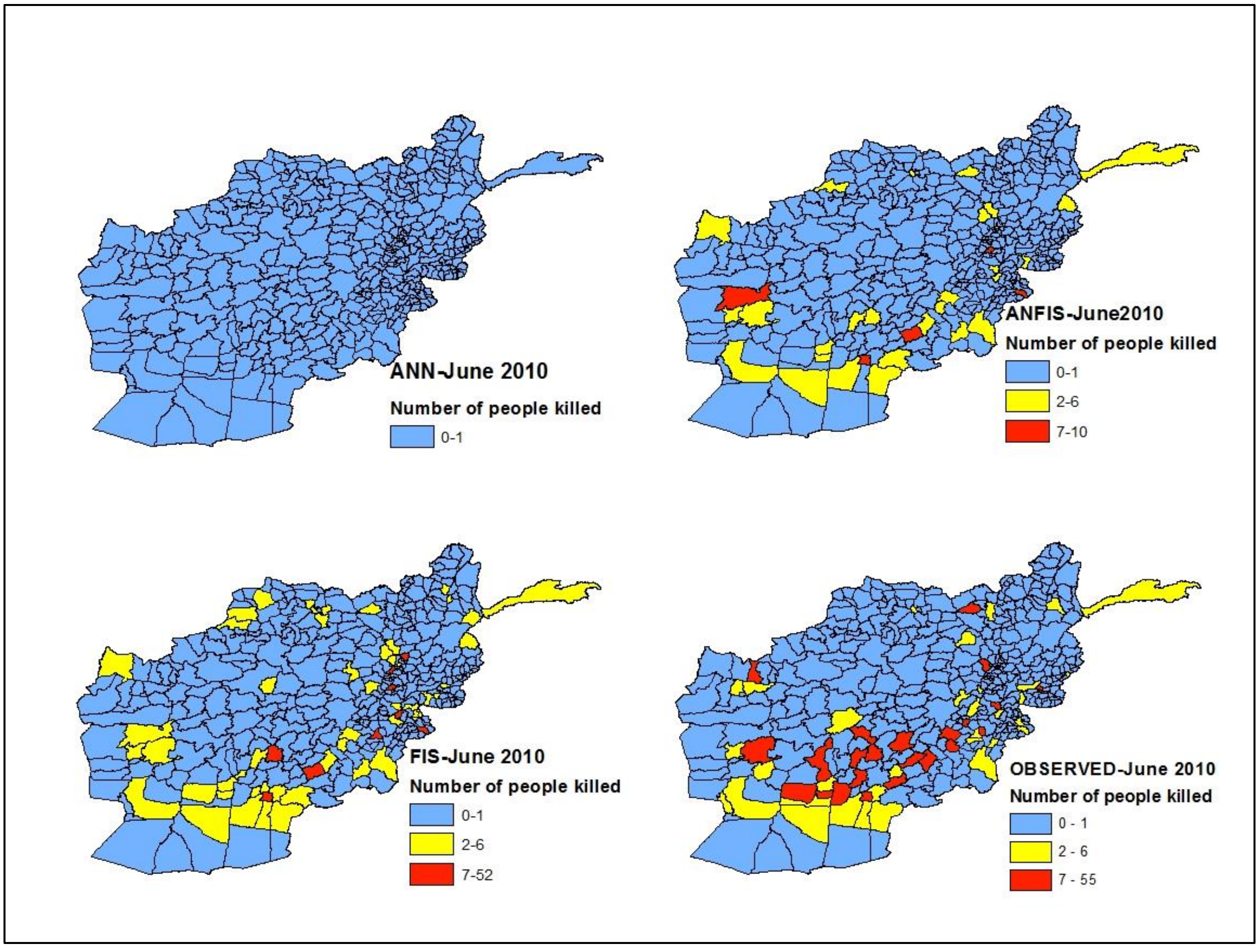


Figure 83: Predicted and observed values of number of people killed for each district in June 2010

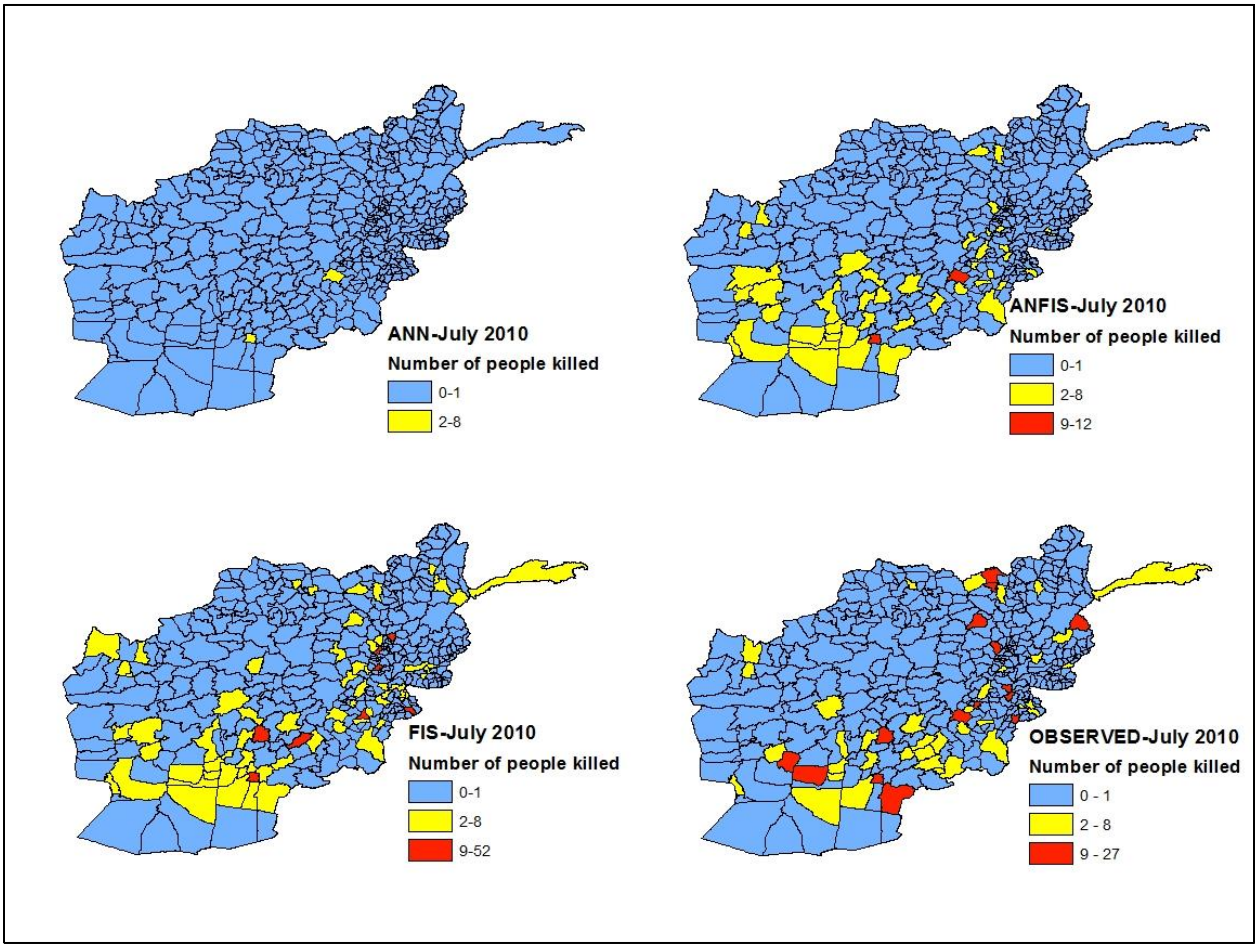


Figure 84: Predicted and observed values of number of people killed for each district in July 2010

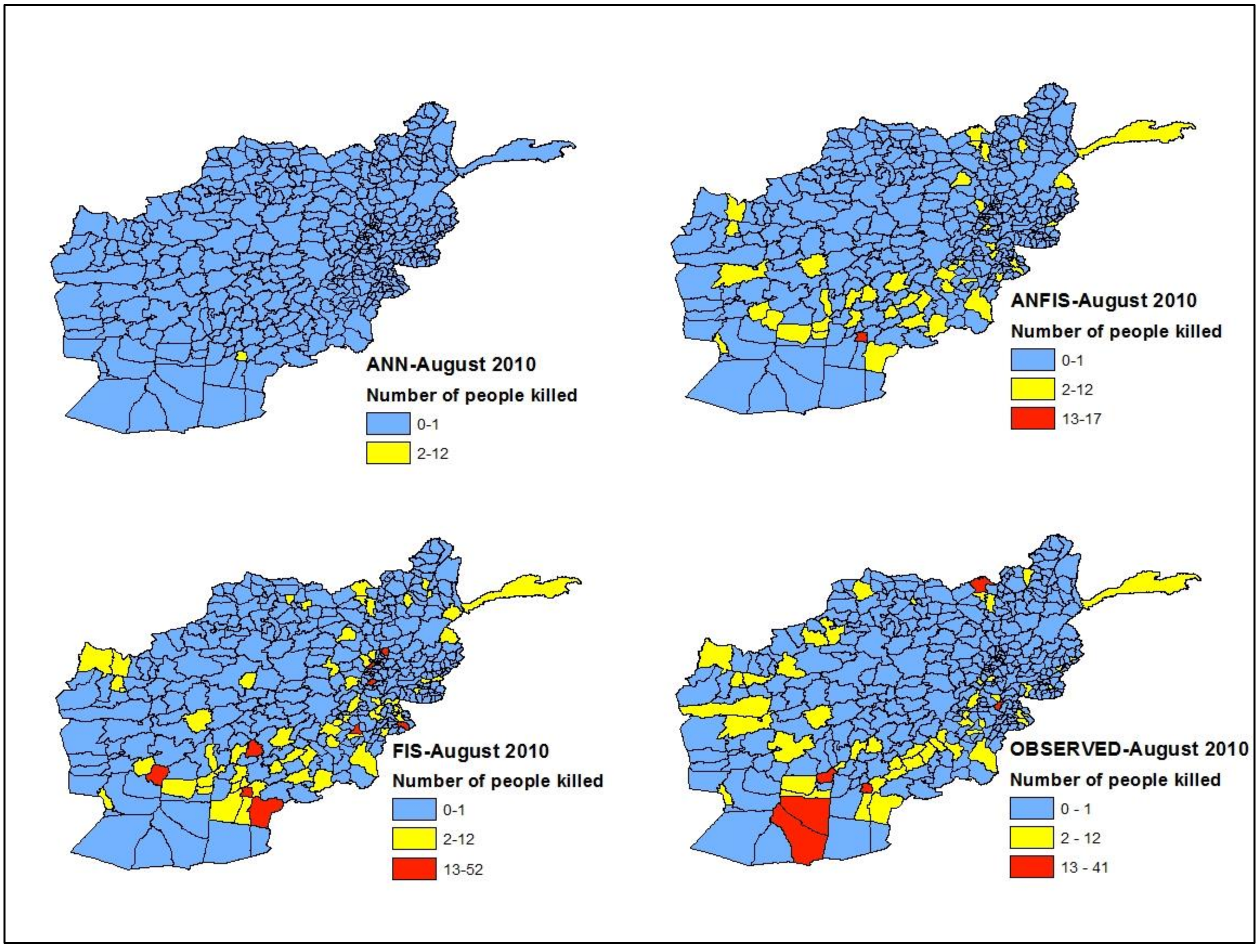


Figure 85: Predicted and observed values of number of people killed for each district in August 2010

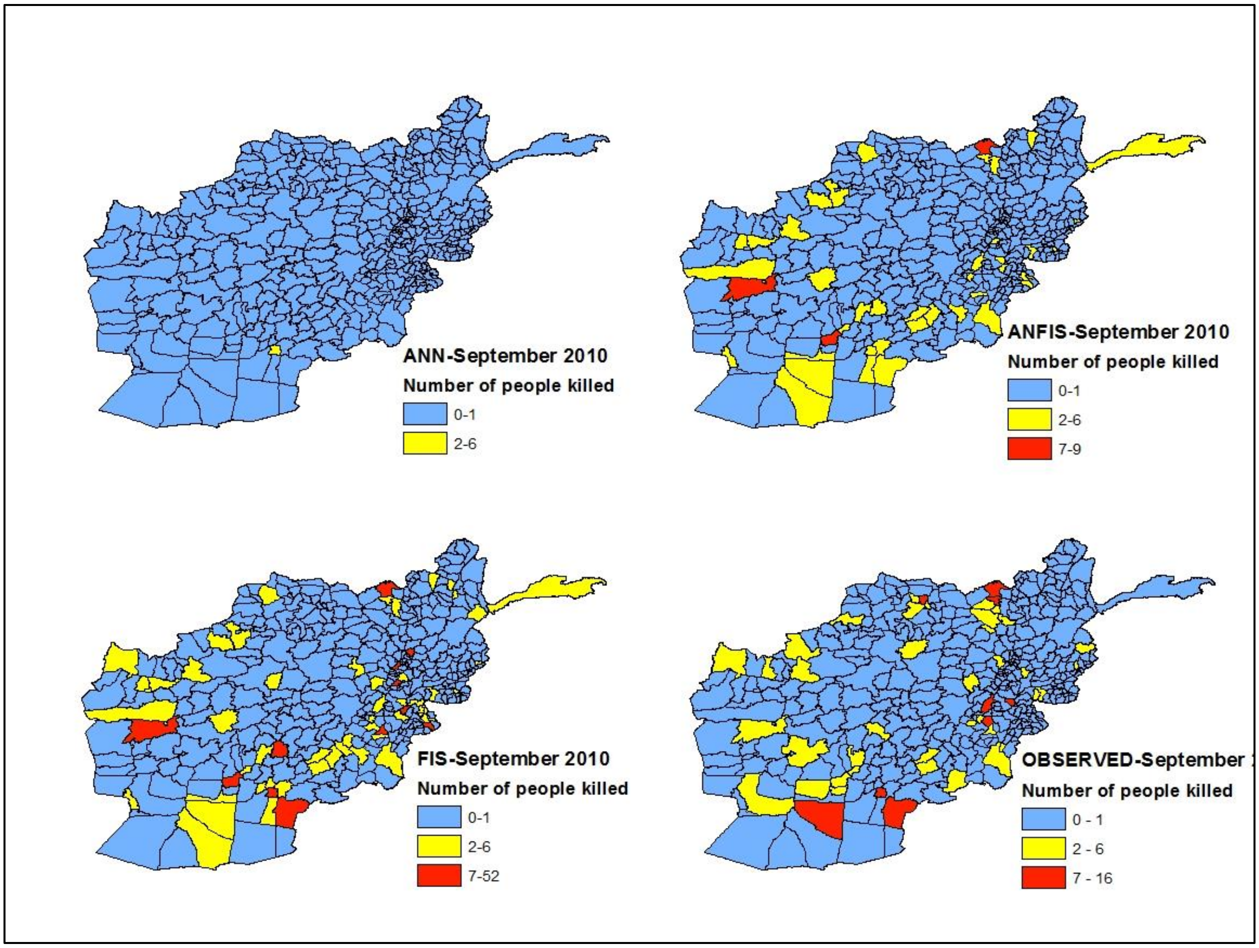


Figure 86: Predicted and observed values of number of people killed for each district in September 2010

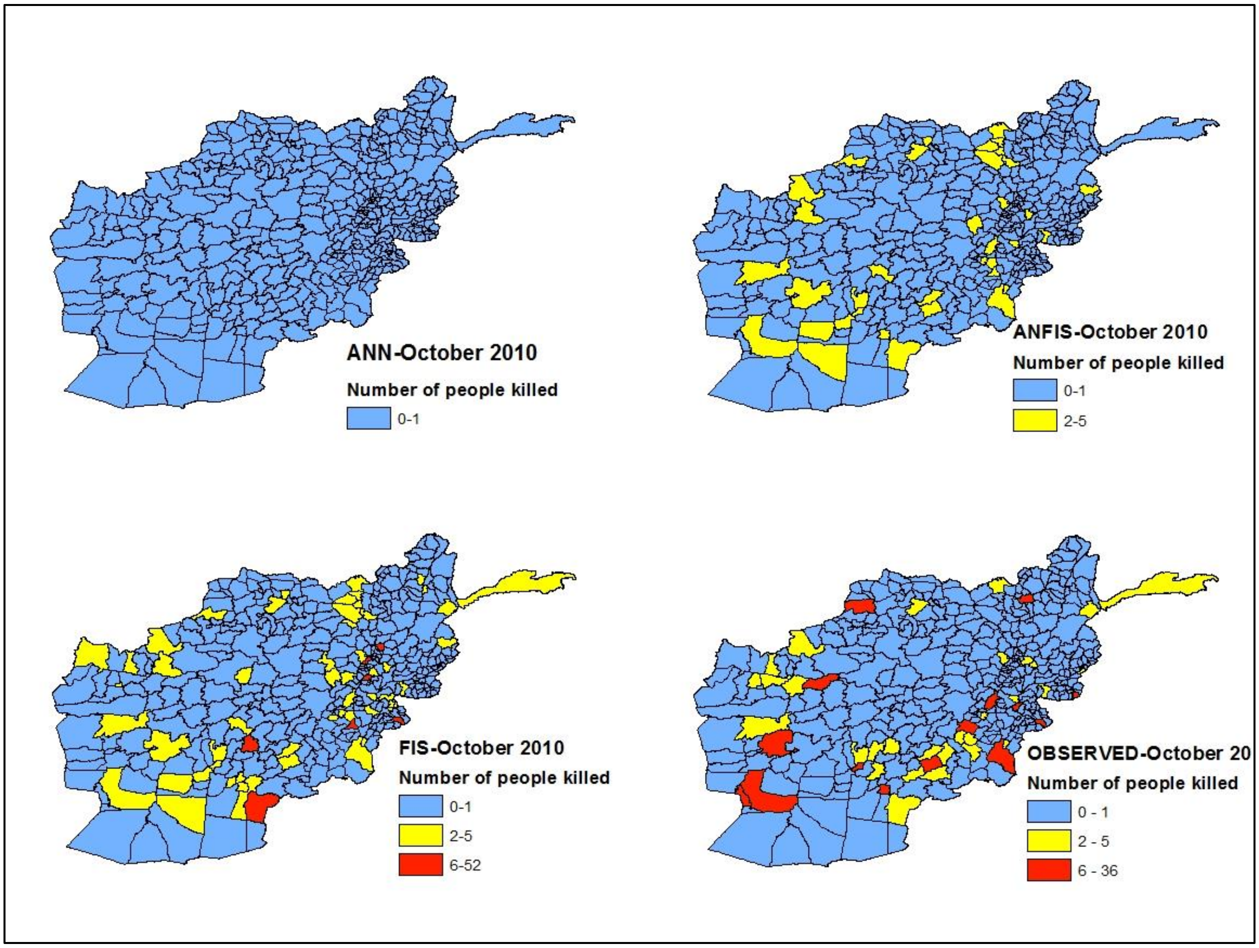


Figure 87: Predicted and observed values of number of people killed for each district in October 2010

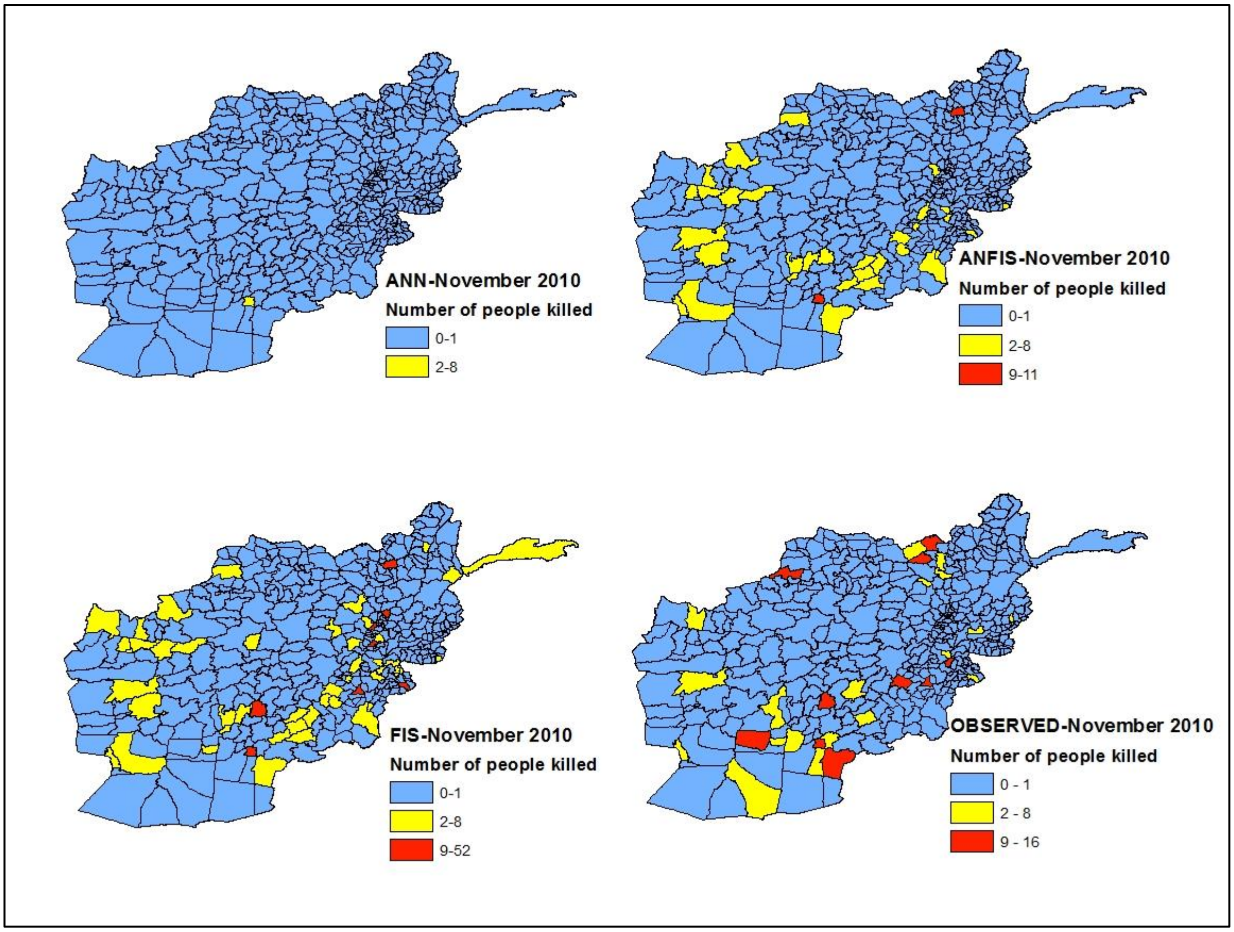


Figure 88: Predicted and observed values of number of people killed for each district in November 2010

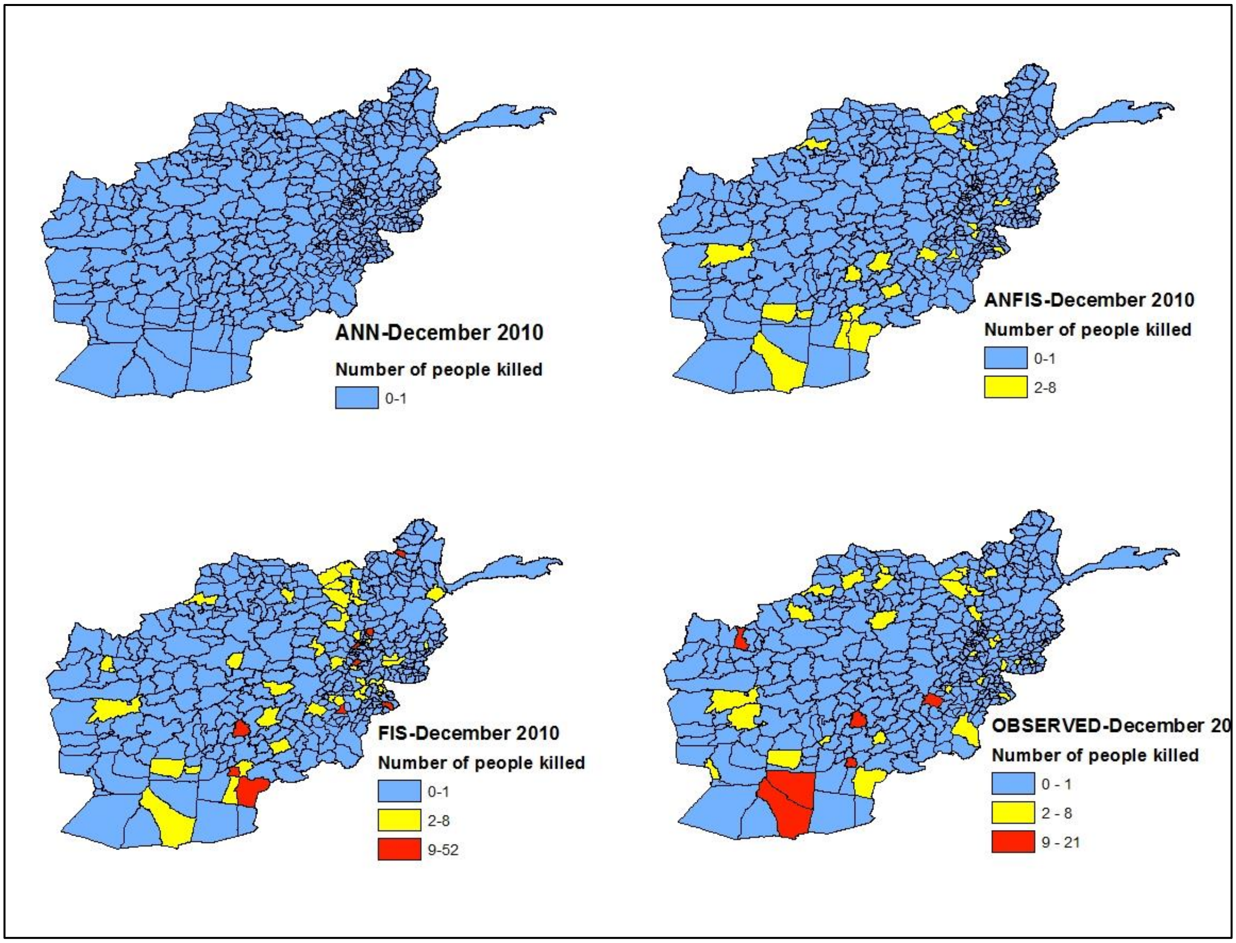


Figure 89: Predicted and observed values of number of people killed for each district in December 2010

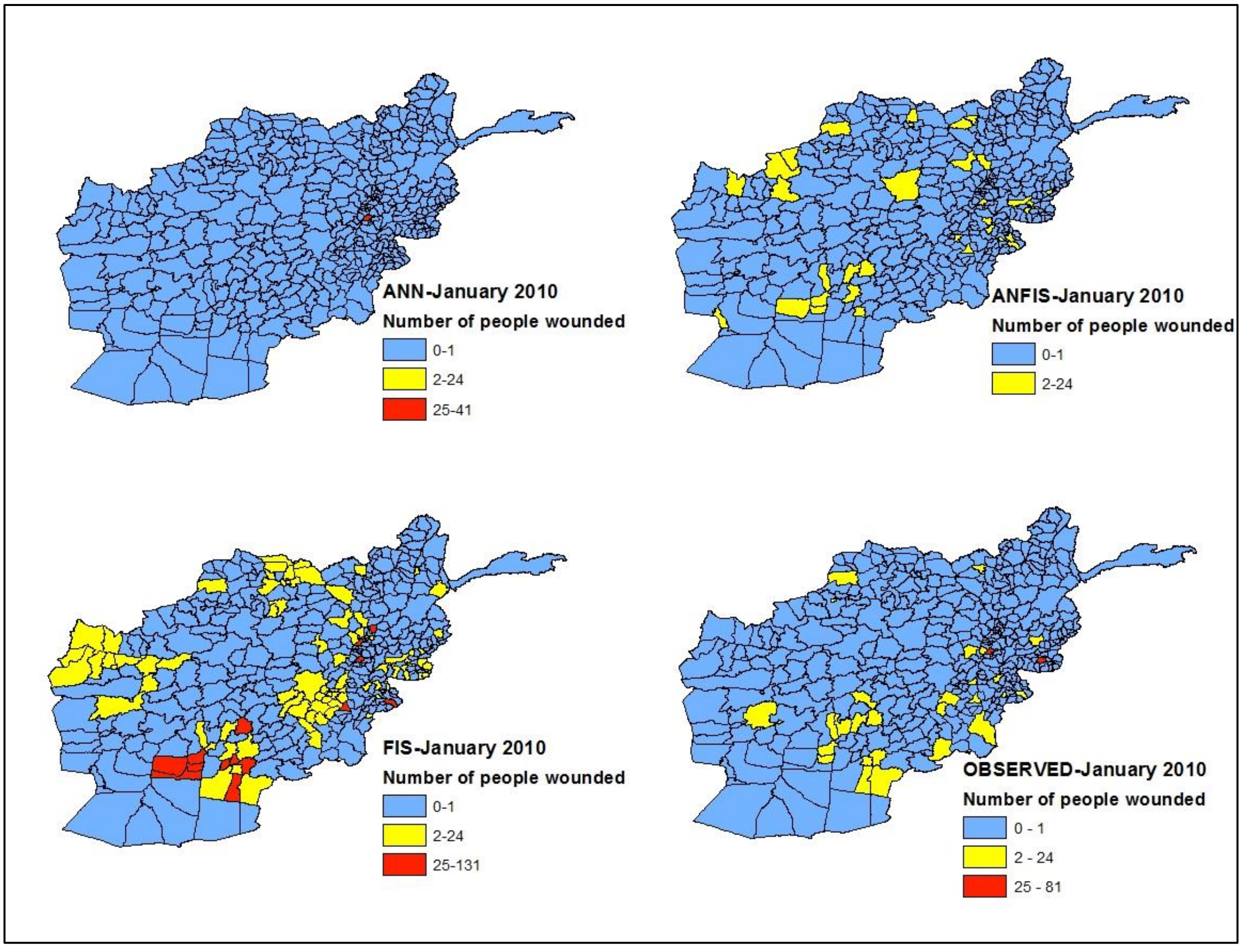


Figure 90: Predicted and observed values of number of people wounded for each district in January 2010

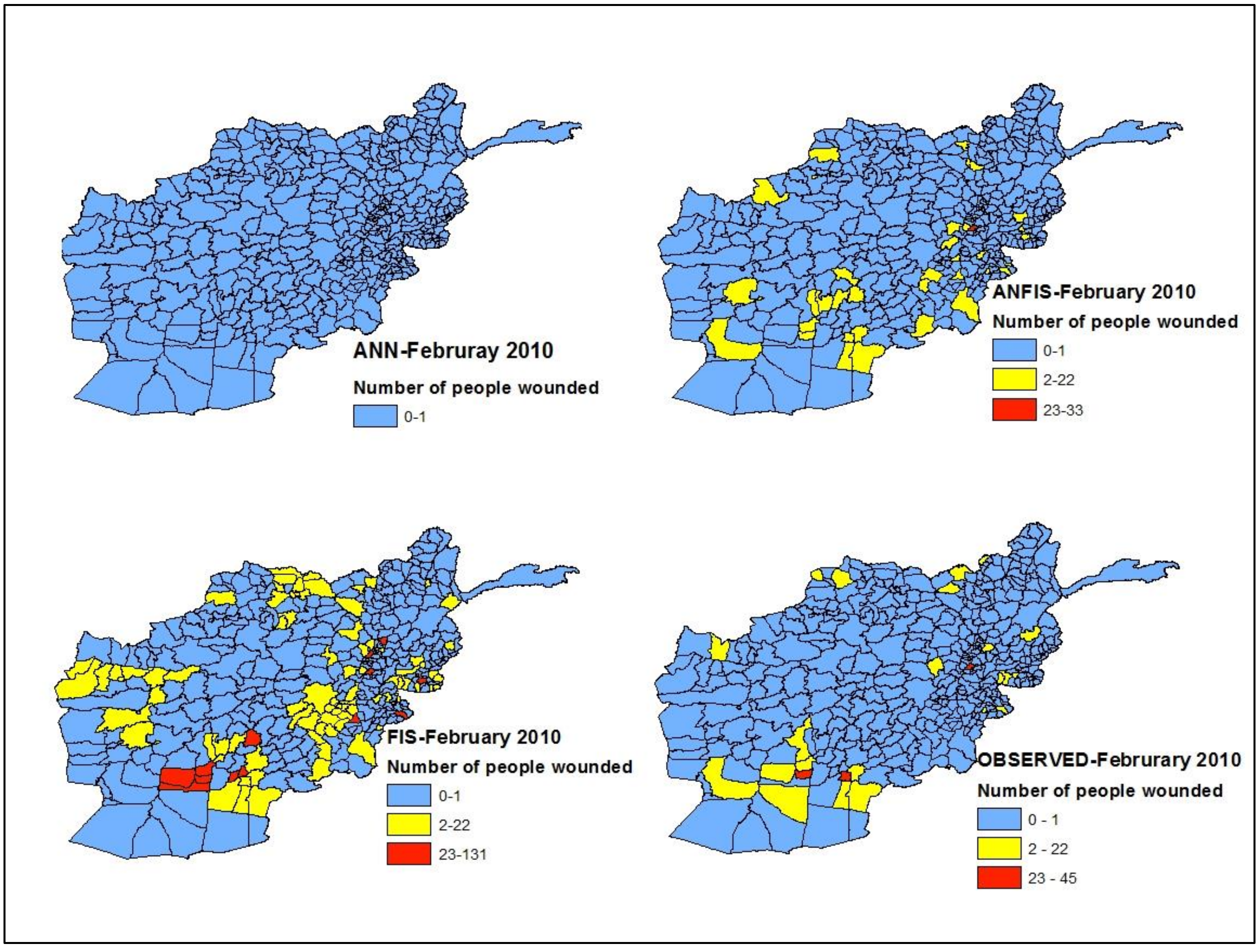


Figure 91: Predicted and observed values of number of people wounded for each district in February 2010

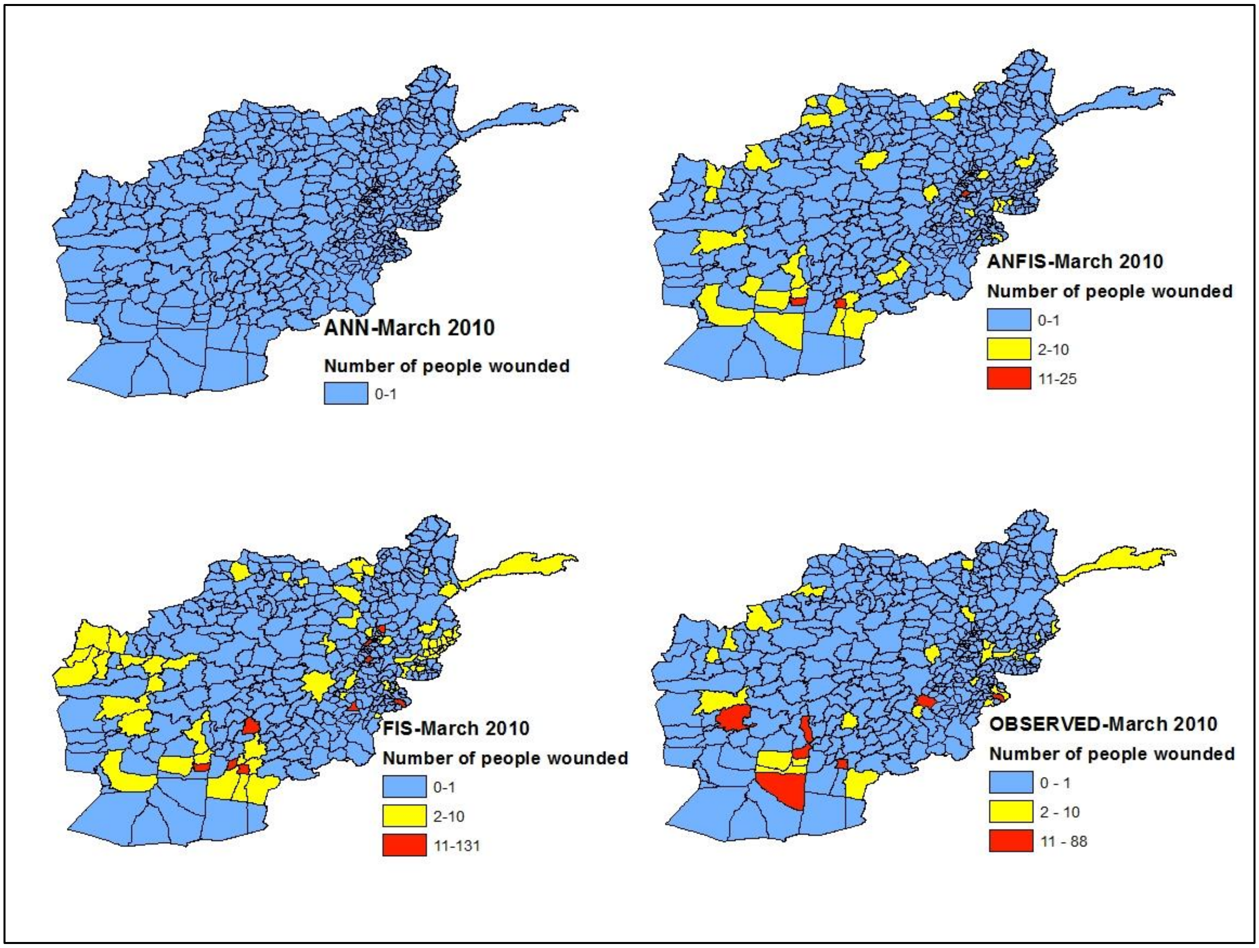


Figure 92: Predicted and observed values of number of people wounded for each district in March 2010

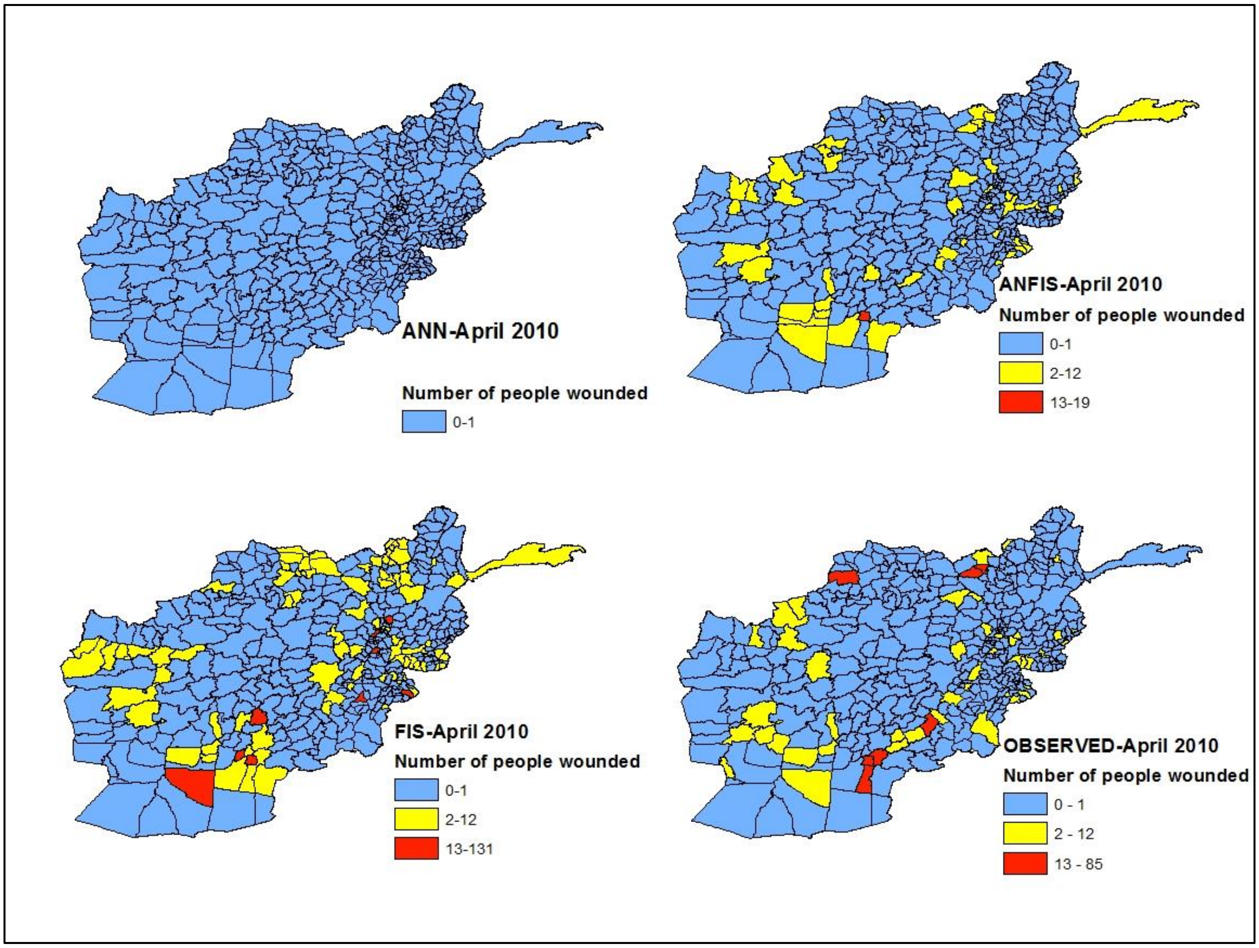


Figure 93: Predicted and observed values of number of people wounded for each district in April 2010

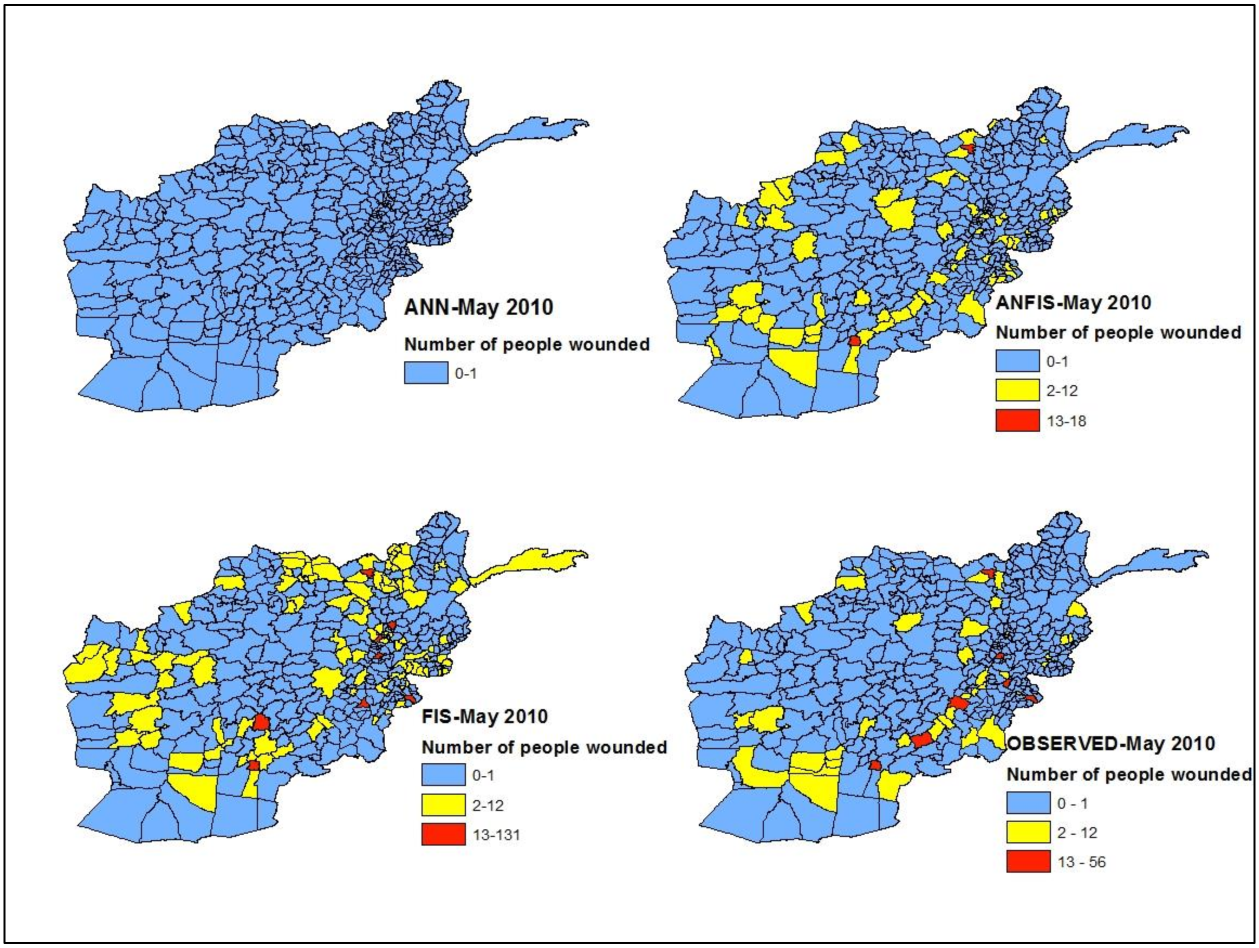


Figure 94: Predicted and observed values of number of people wounded for each district in May 2010

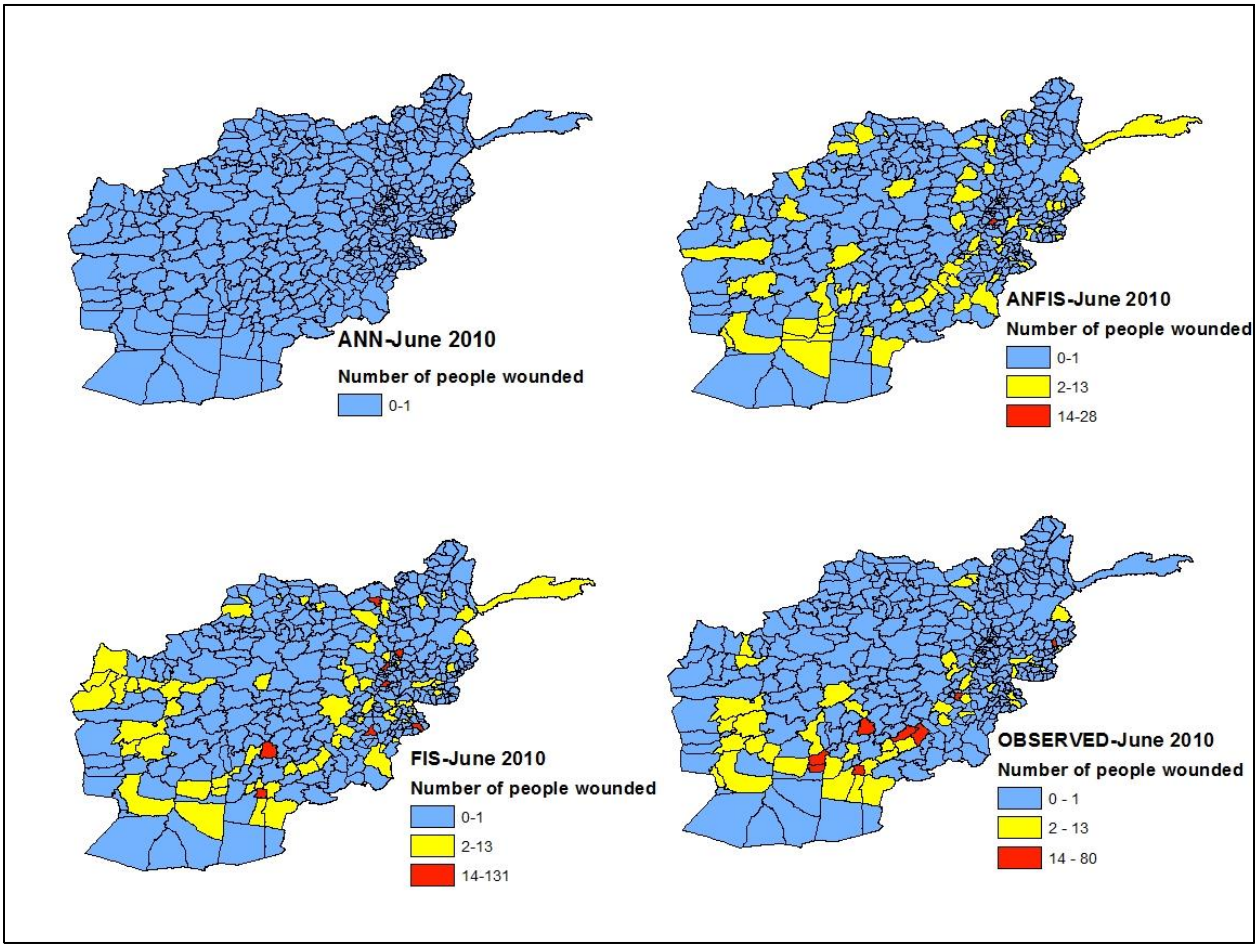


Figure 95: Predicted and observed values of number of people wounded for each district in June 2010

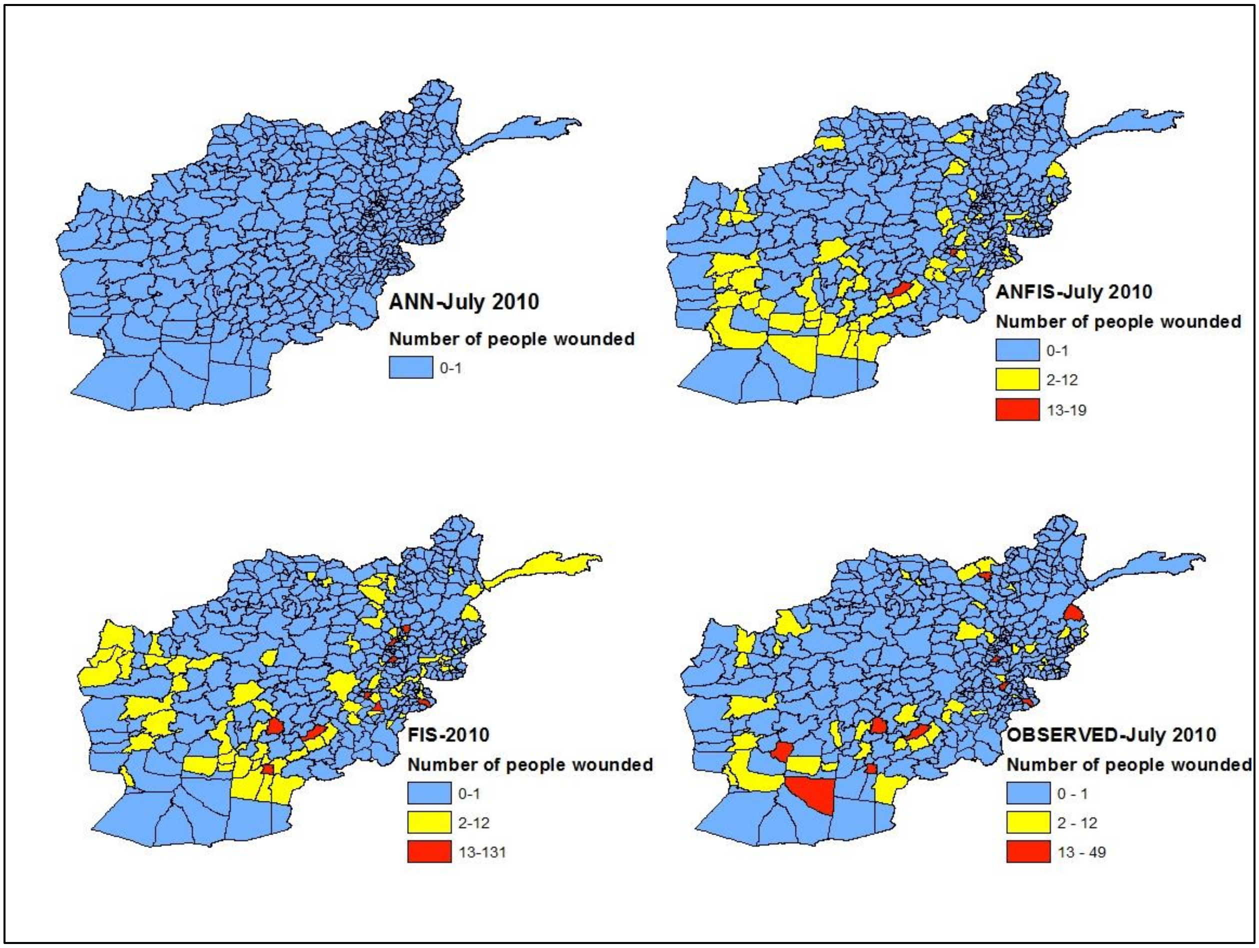


Figure 96: Predicted and observed values of number of people wounded for each district in July 2010

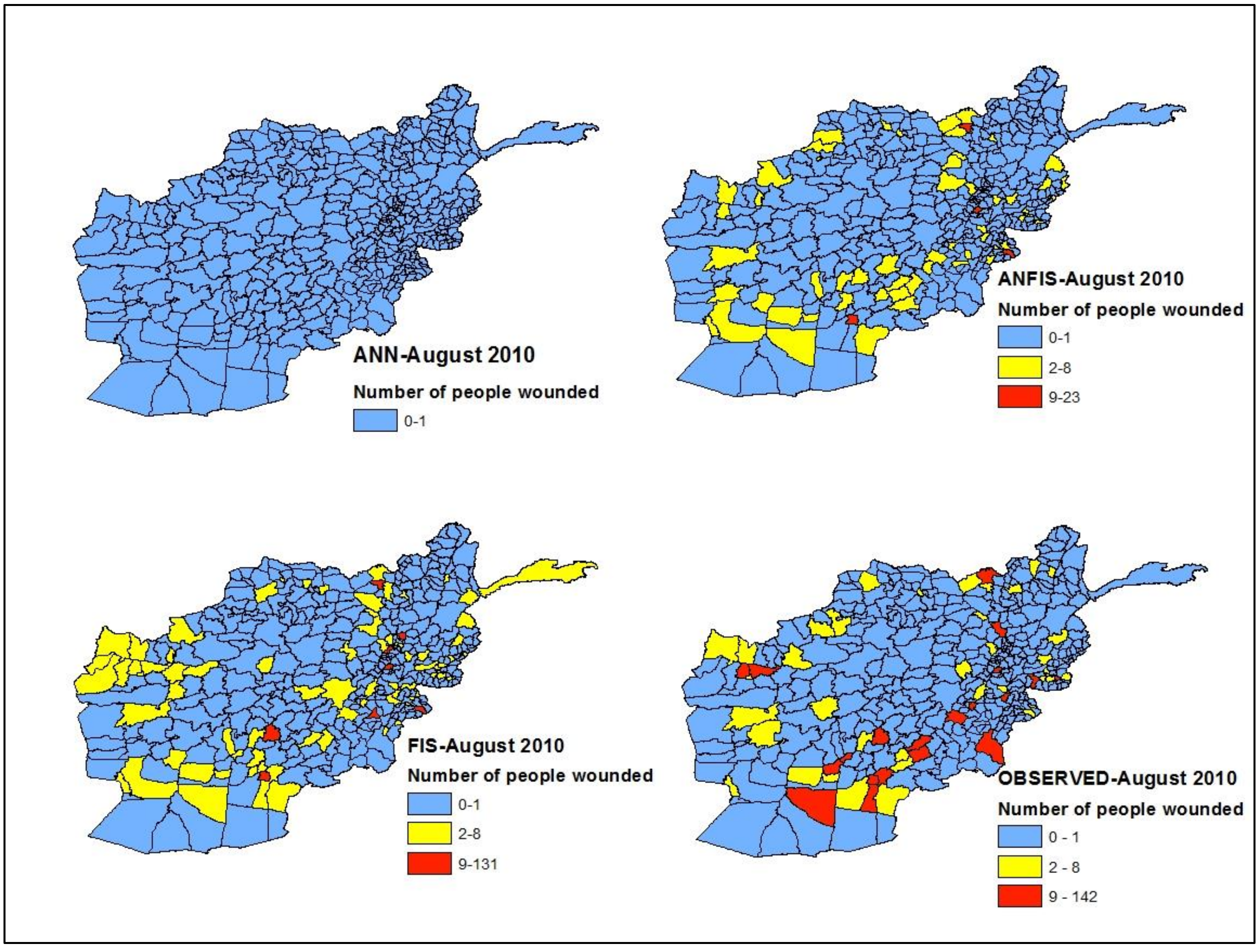


Figure 97: Predicted and observed values of number of people wounded for each district in August 2010

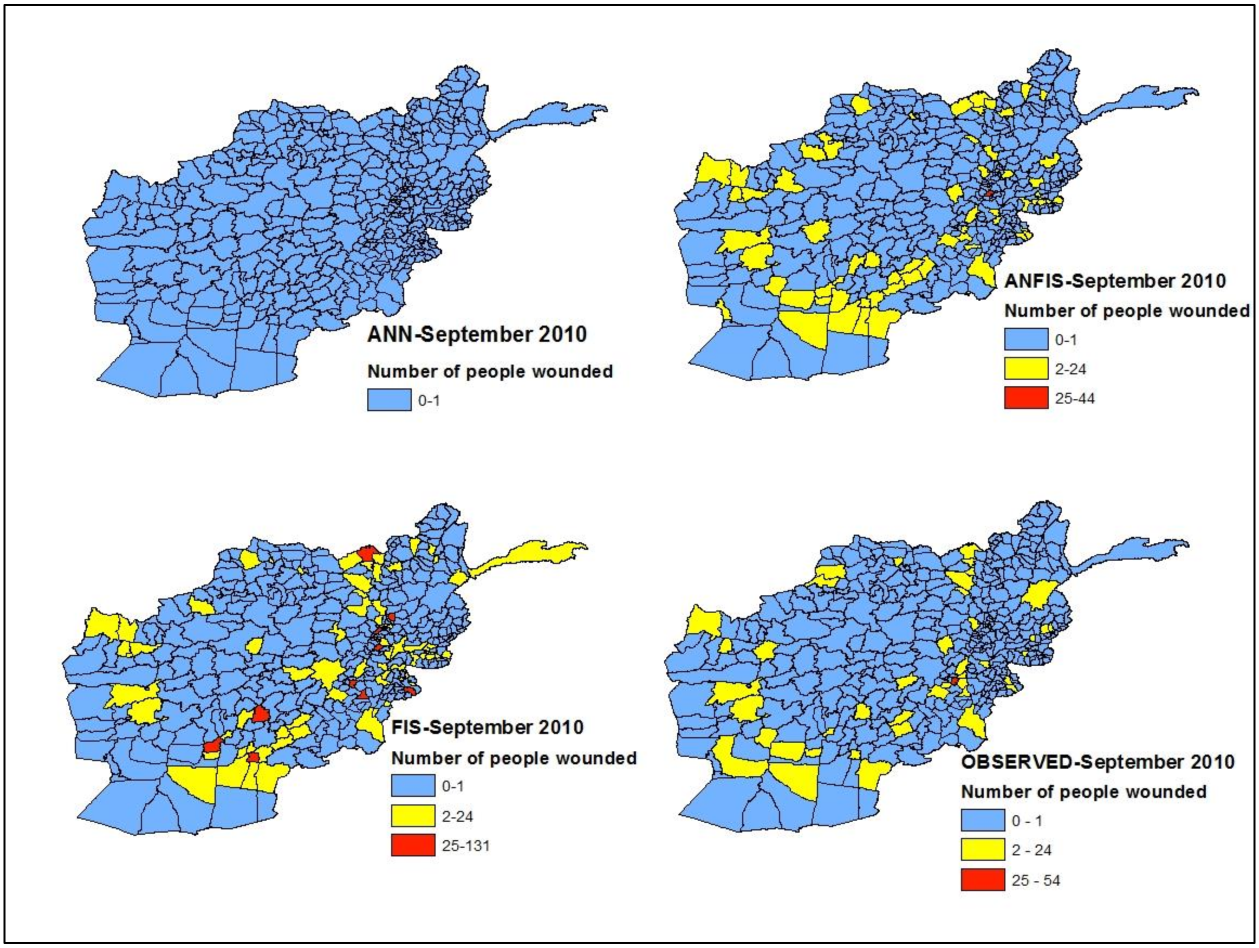


Figure 98: Predicted and observed values of number of people wounded for each district in September 2010

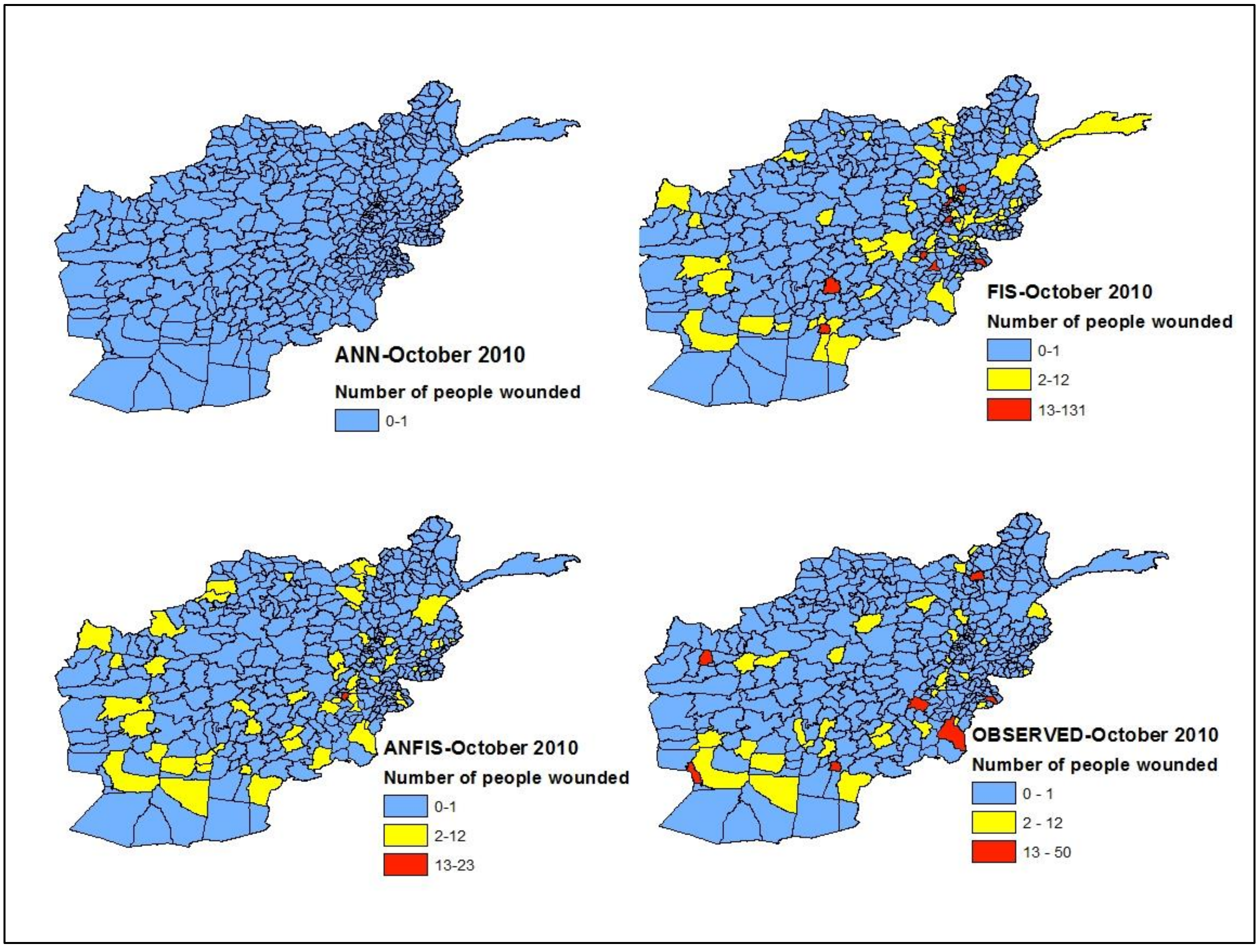


Figure 99: Predicted and observed values of number of people wounded for each district in October 2010

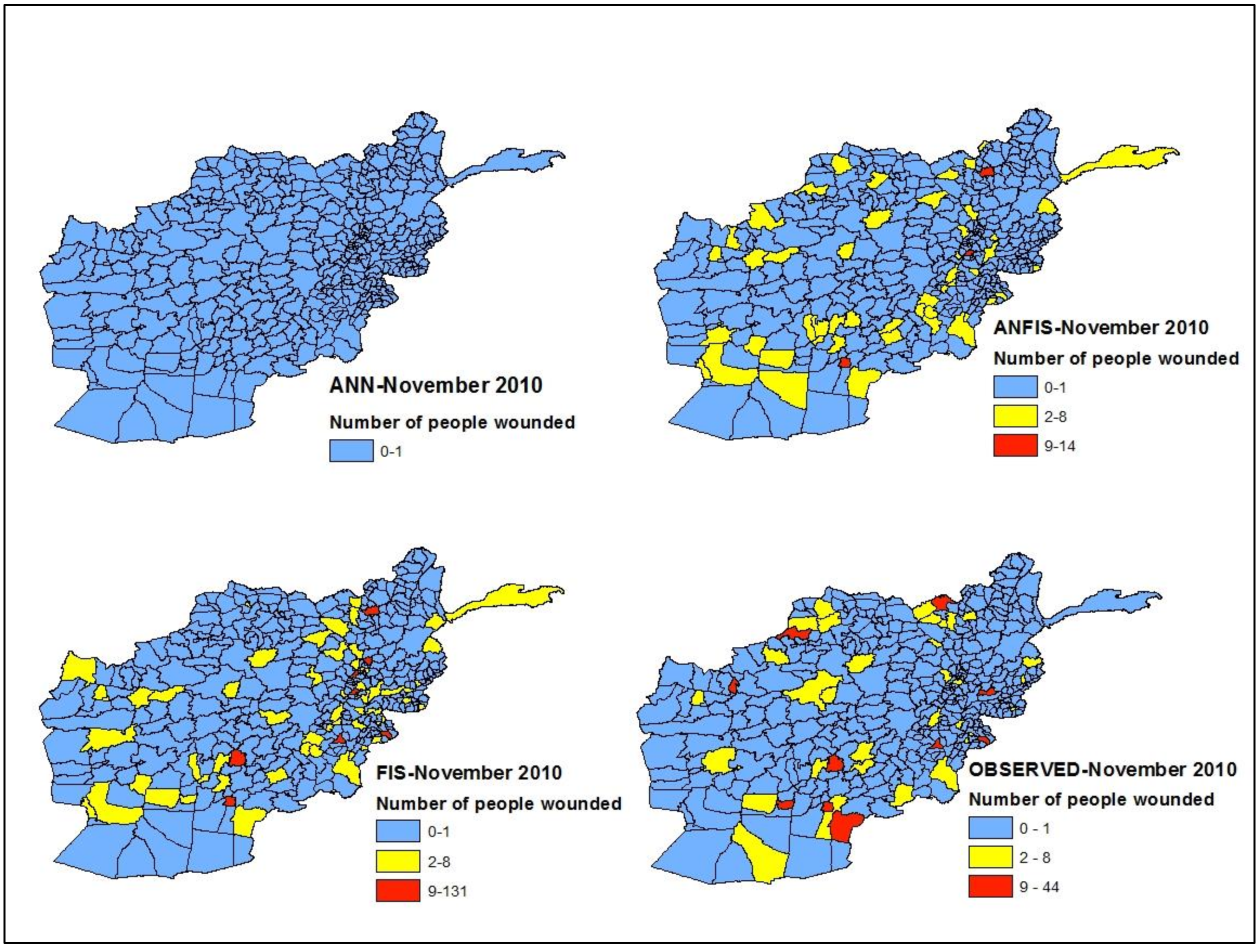


Figure 100: Predicted and observed values of number of people wounded for each district in November 2010

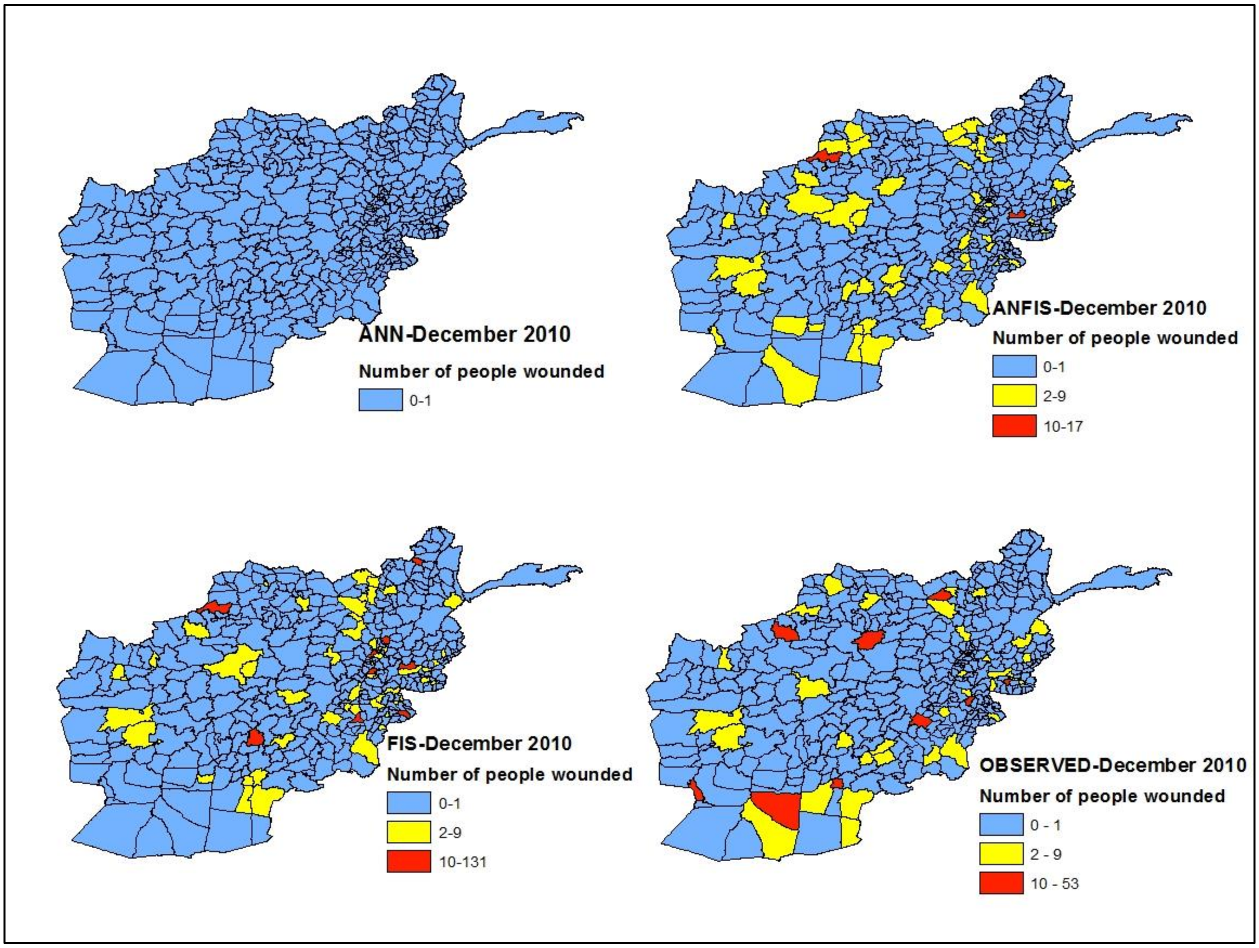


Figure 101: Predicted and observed values of number of people wounded for each district in December 2010

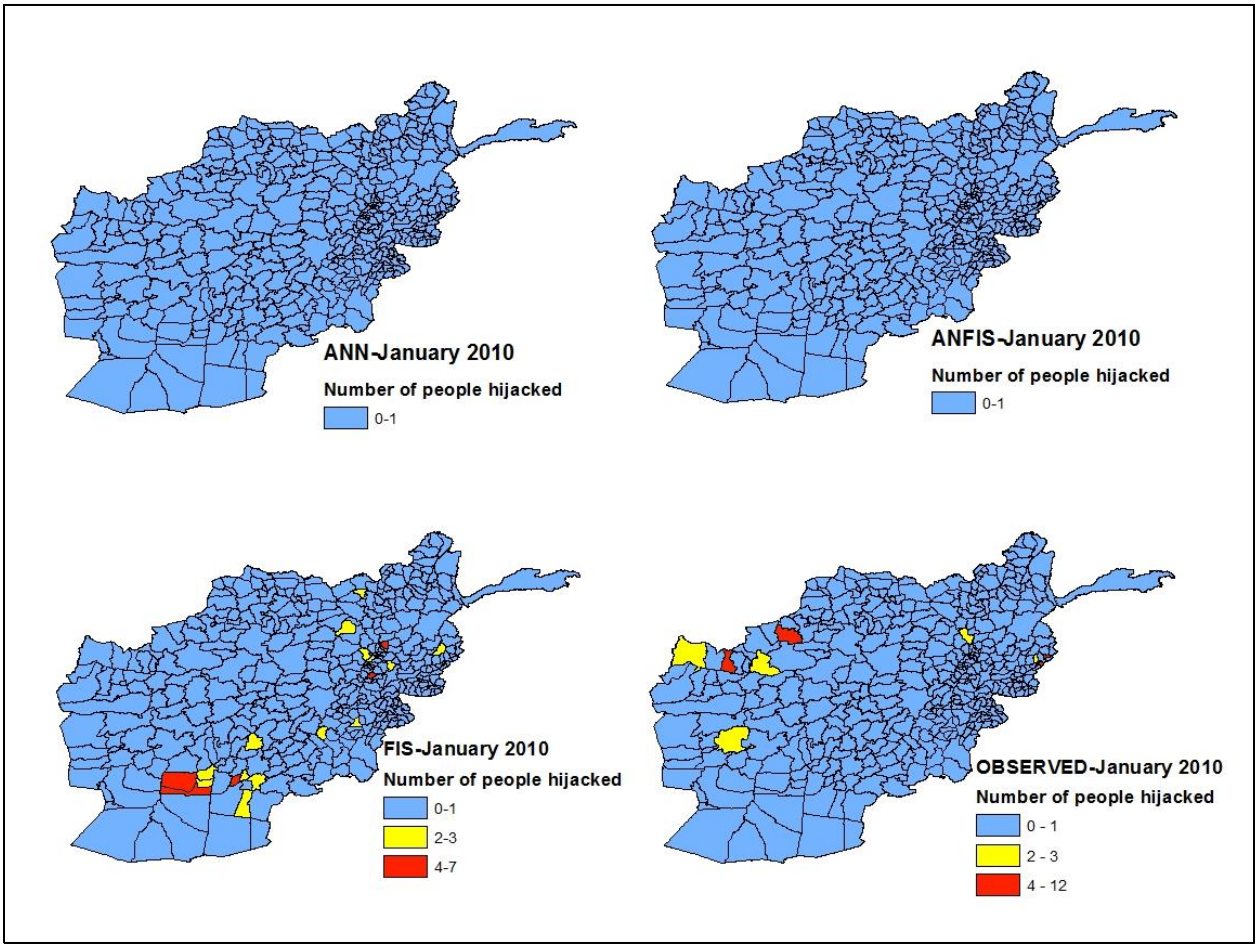


Figure 102: Predicted and observed values of number of people hijacked for each district in January 2010

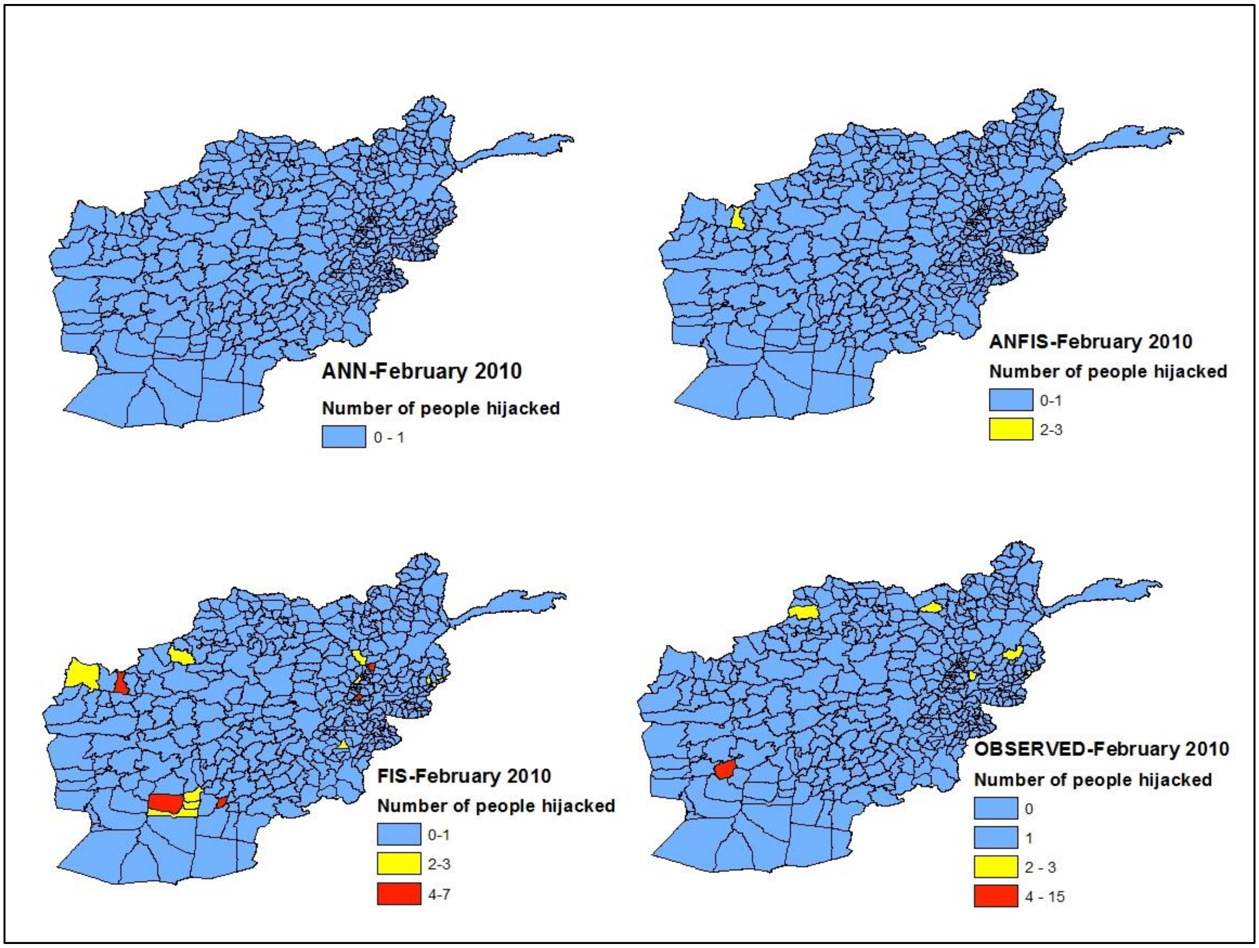


Figure 103: Predicted and observed values of number of people hijacked for each district in February 2010

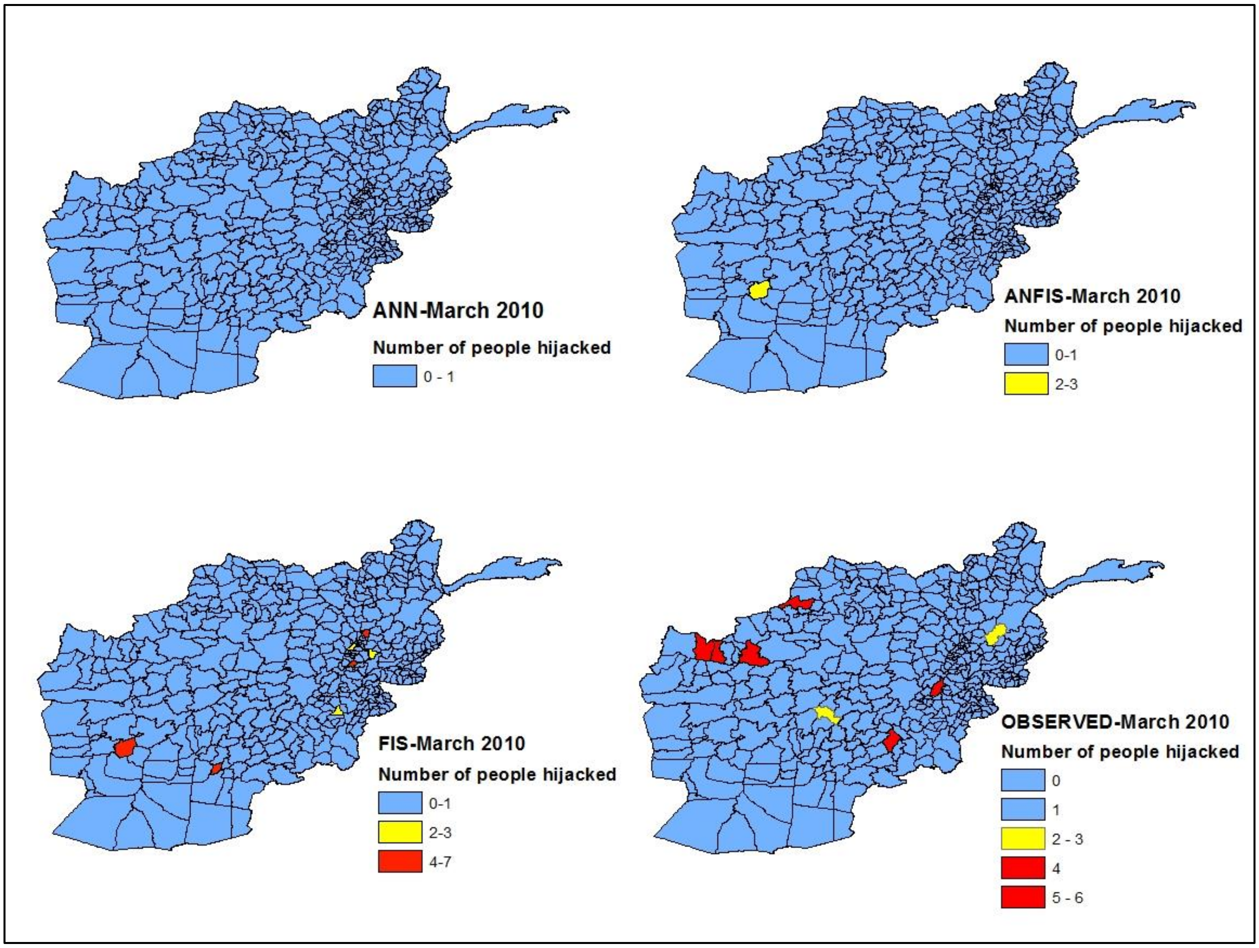


Figure 104: Predicted and observed values of number of people hijacked for each district in March 2010

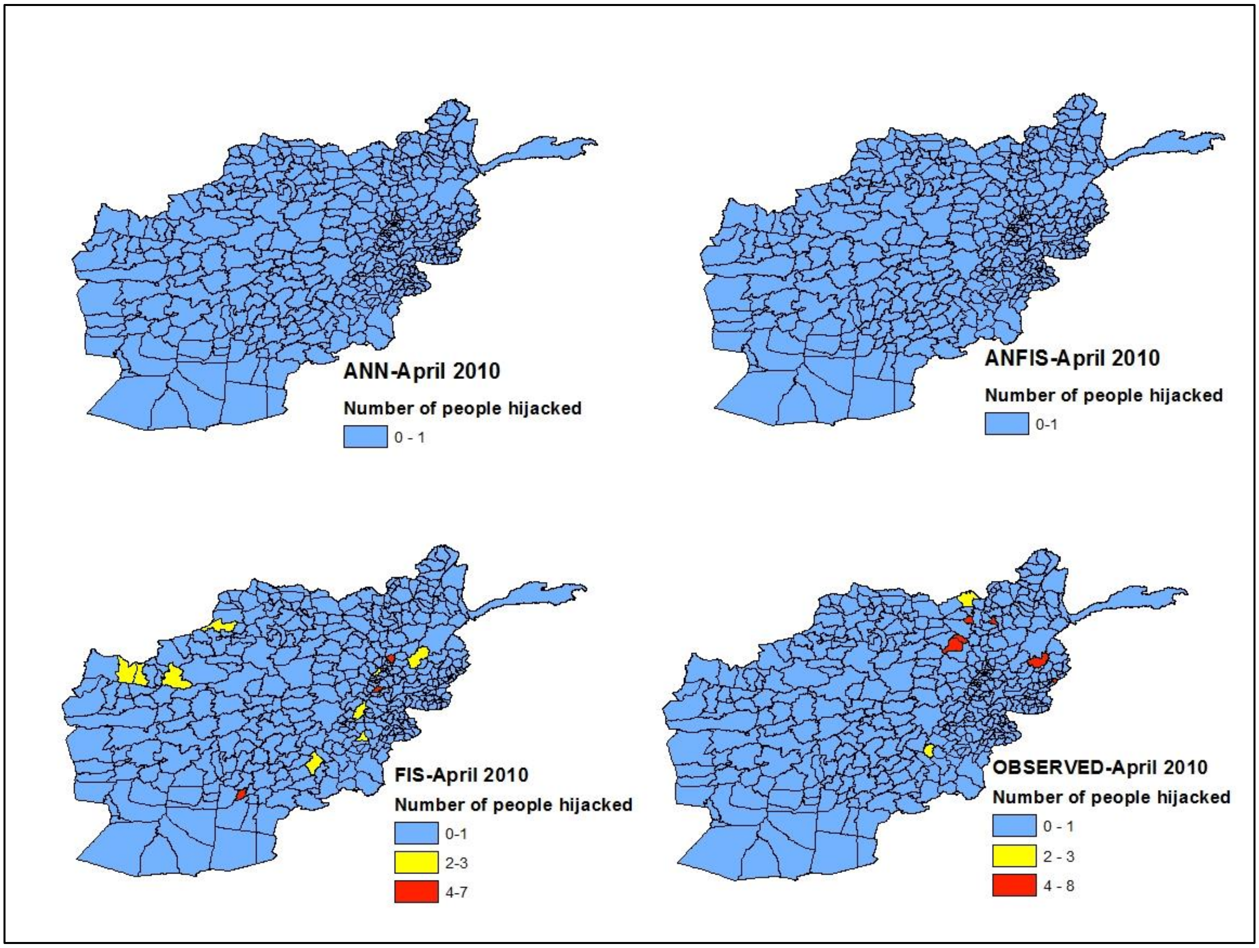


Figure 105: Predicted and observed values of number of people hijacked for each district in April 2010

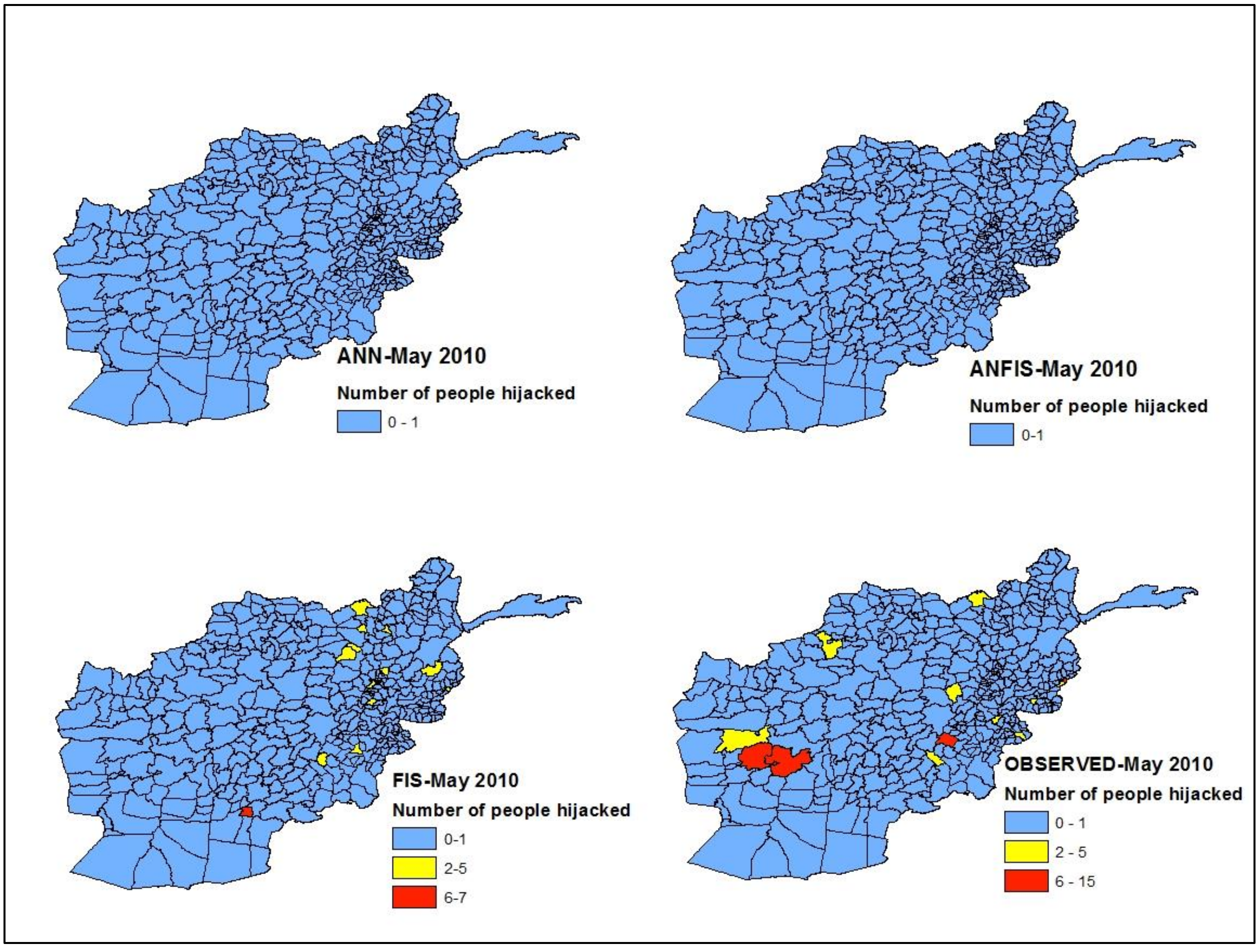


Figure 106: Predicted and observed values of number of people hijacked for each district in May 2010

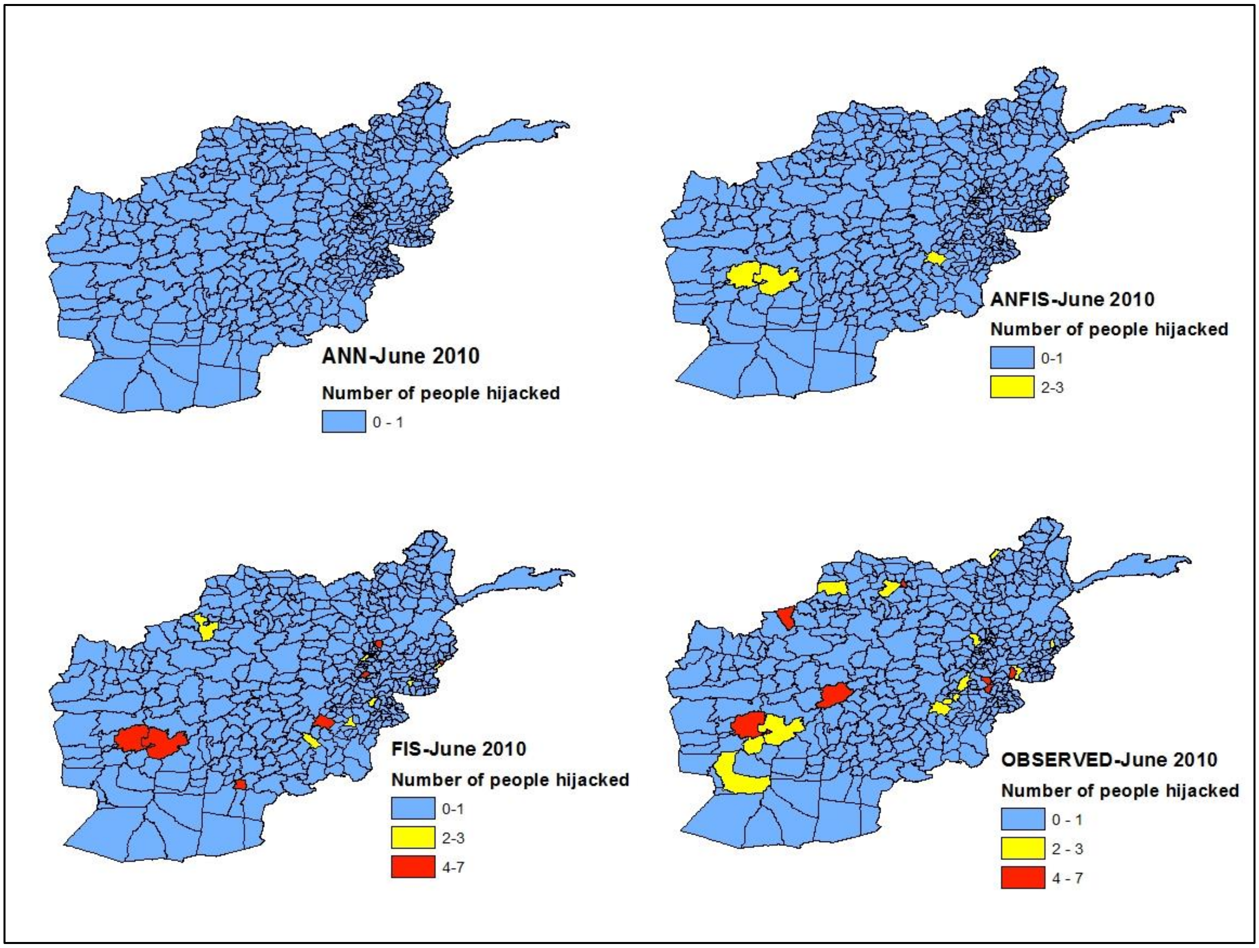


Figure 107: Predicted and observed values of number of people hijacked for each district in June 2010

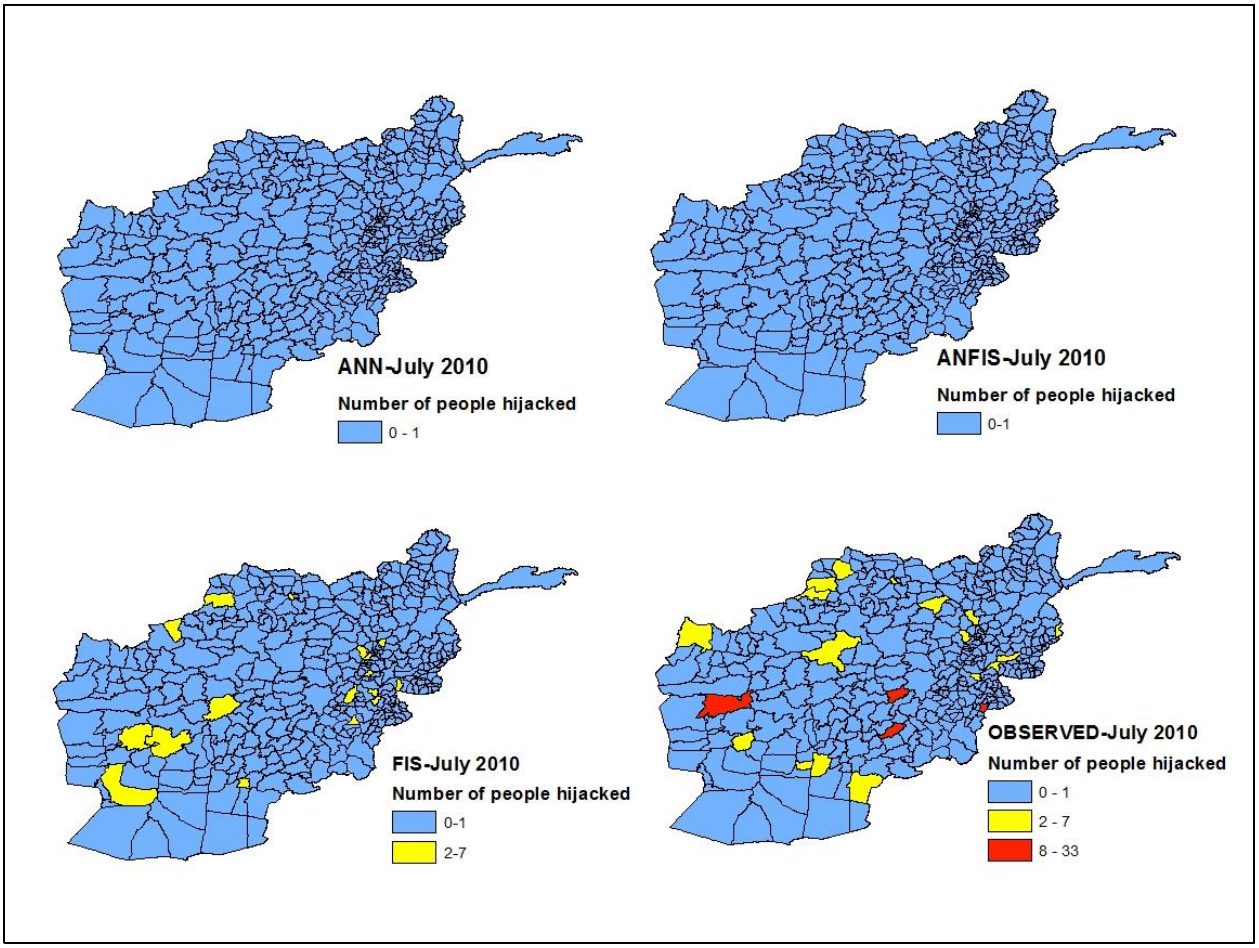


Figure 108: Predicted and observed values of number of people hijacked for each district in July 2010

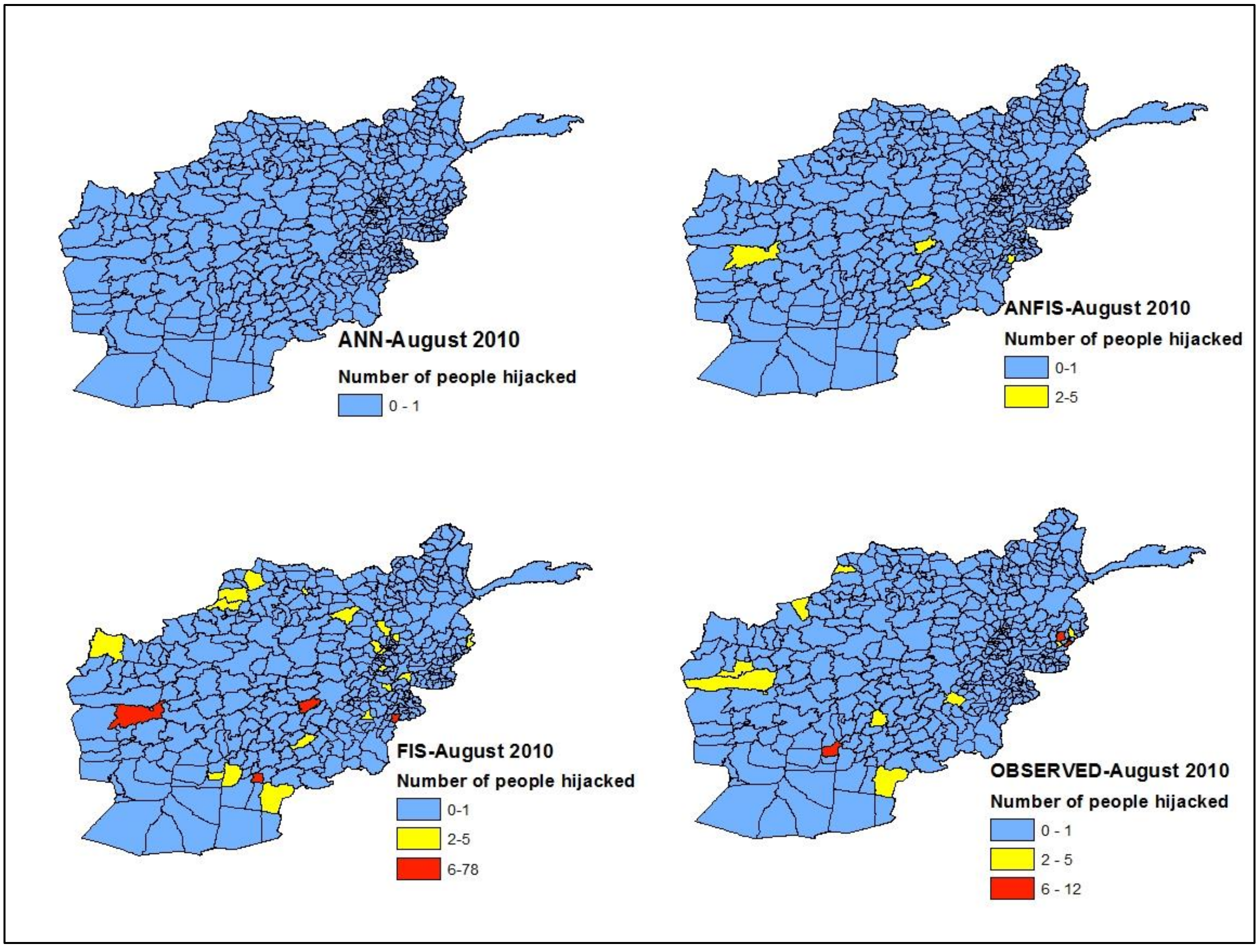


Figure 109: Predicted and observed values of number of people hijacked for each district in August 2010

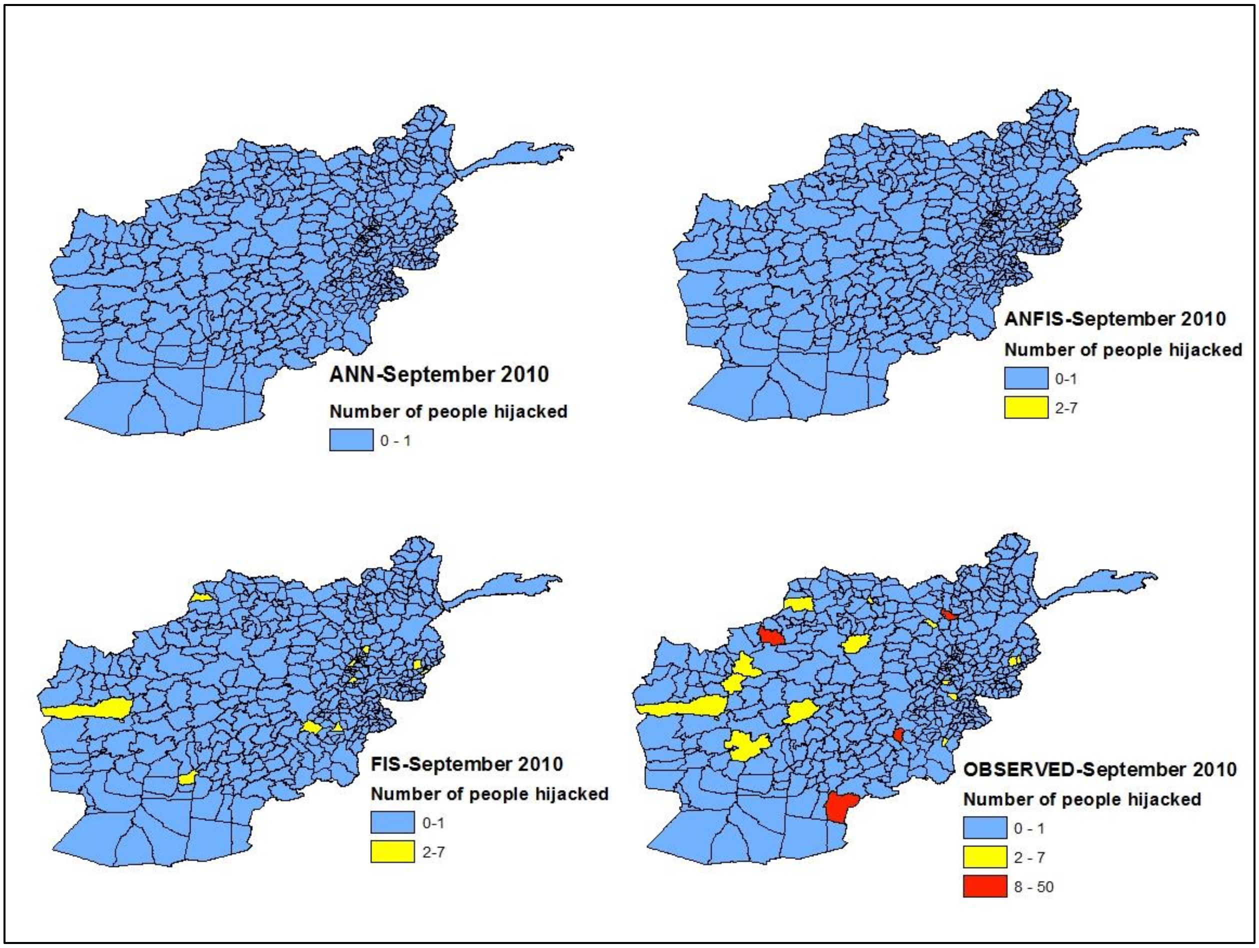


Figure 110: Predicted and observed values of number of people hijacked for each district in September 2010

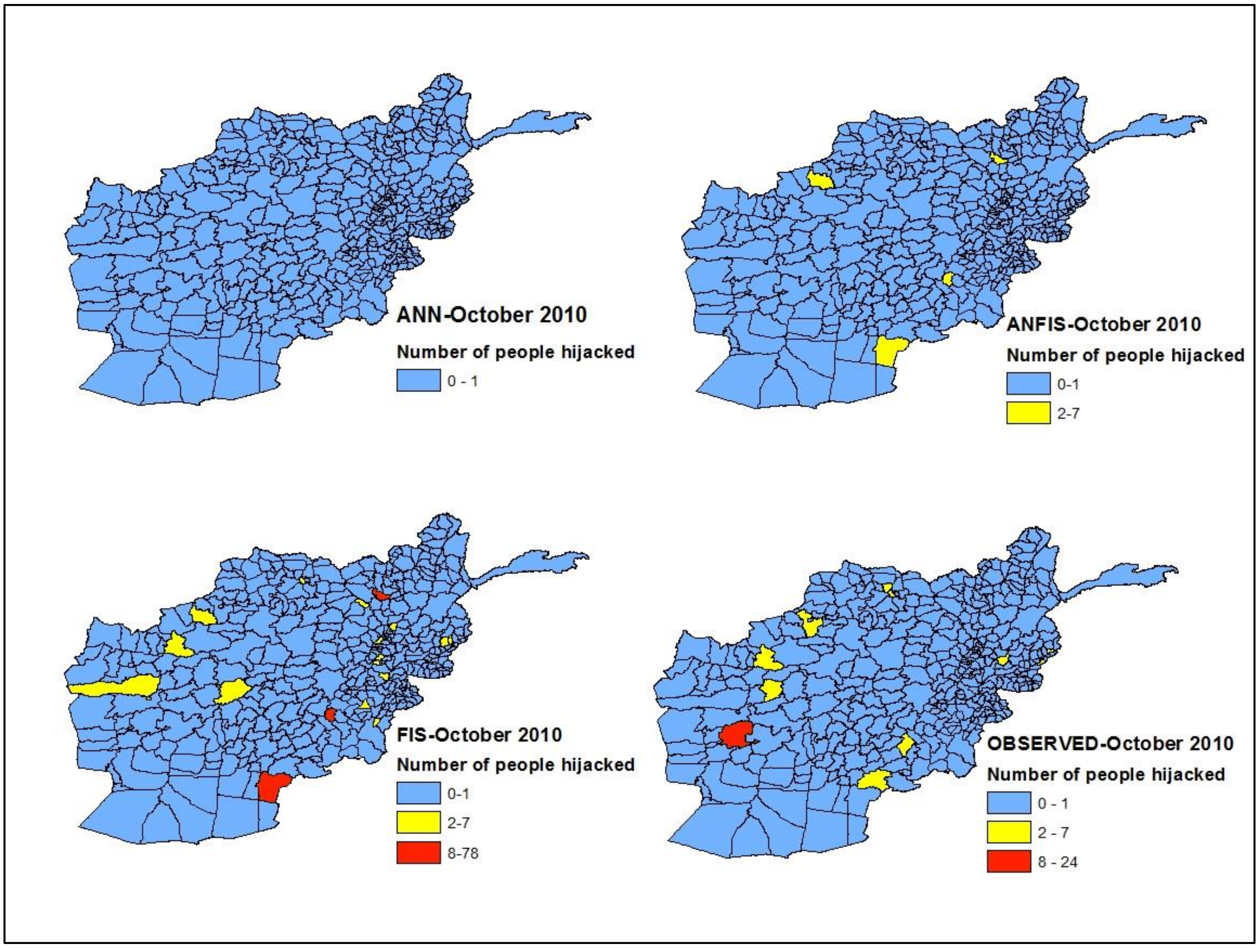


Figure 111: Predicted and observed values of number of people hijacked for each district in October 2010

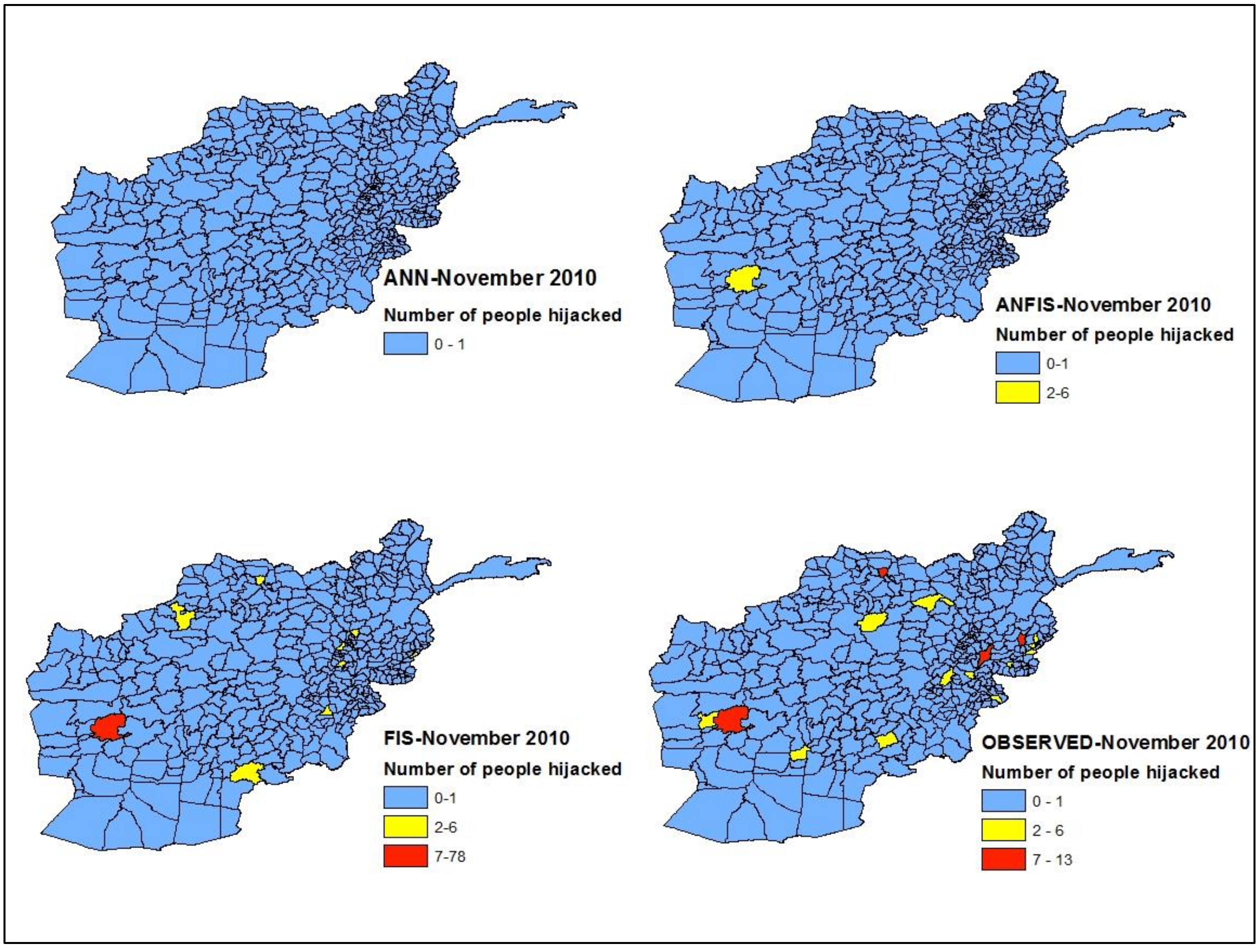


Figure 112: Predicted and observed values of number of people hijacked for each district in November 2010

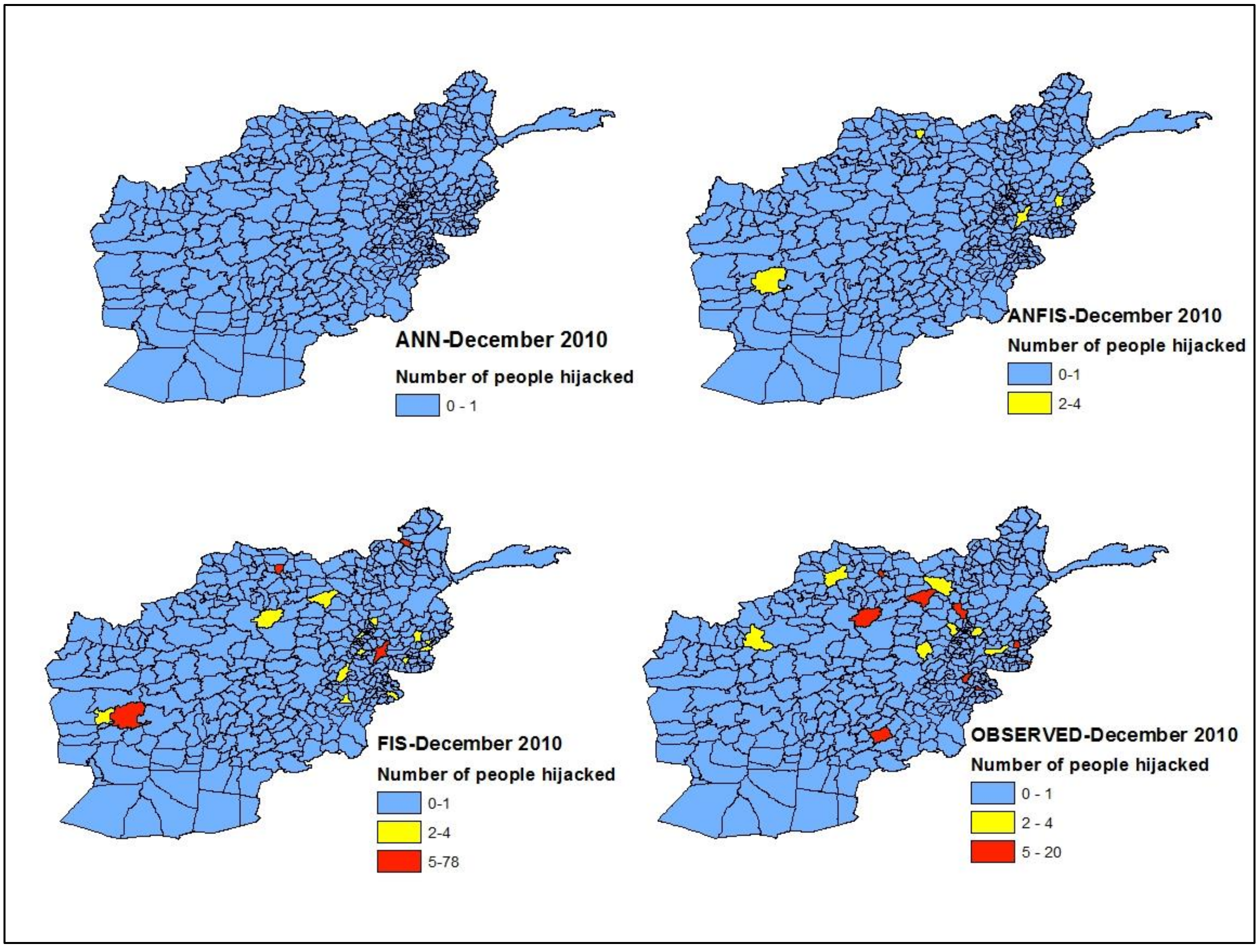


Figure 113: Predicted and observed values of number of people hijacked for each district in December 2010

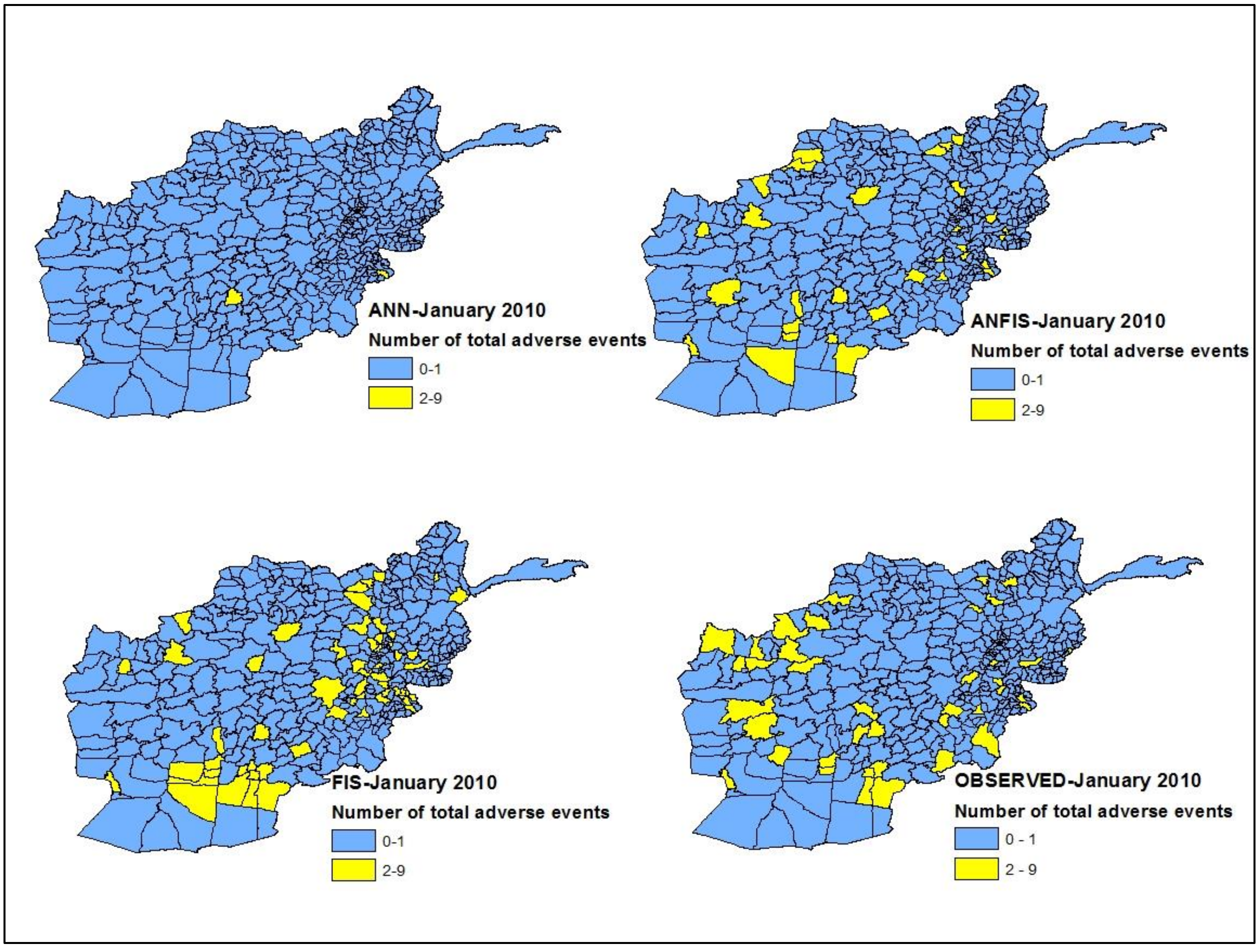


Figure 114: Predicted and observed values of number of total adverse events for each district in January 2010

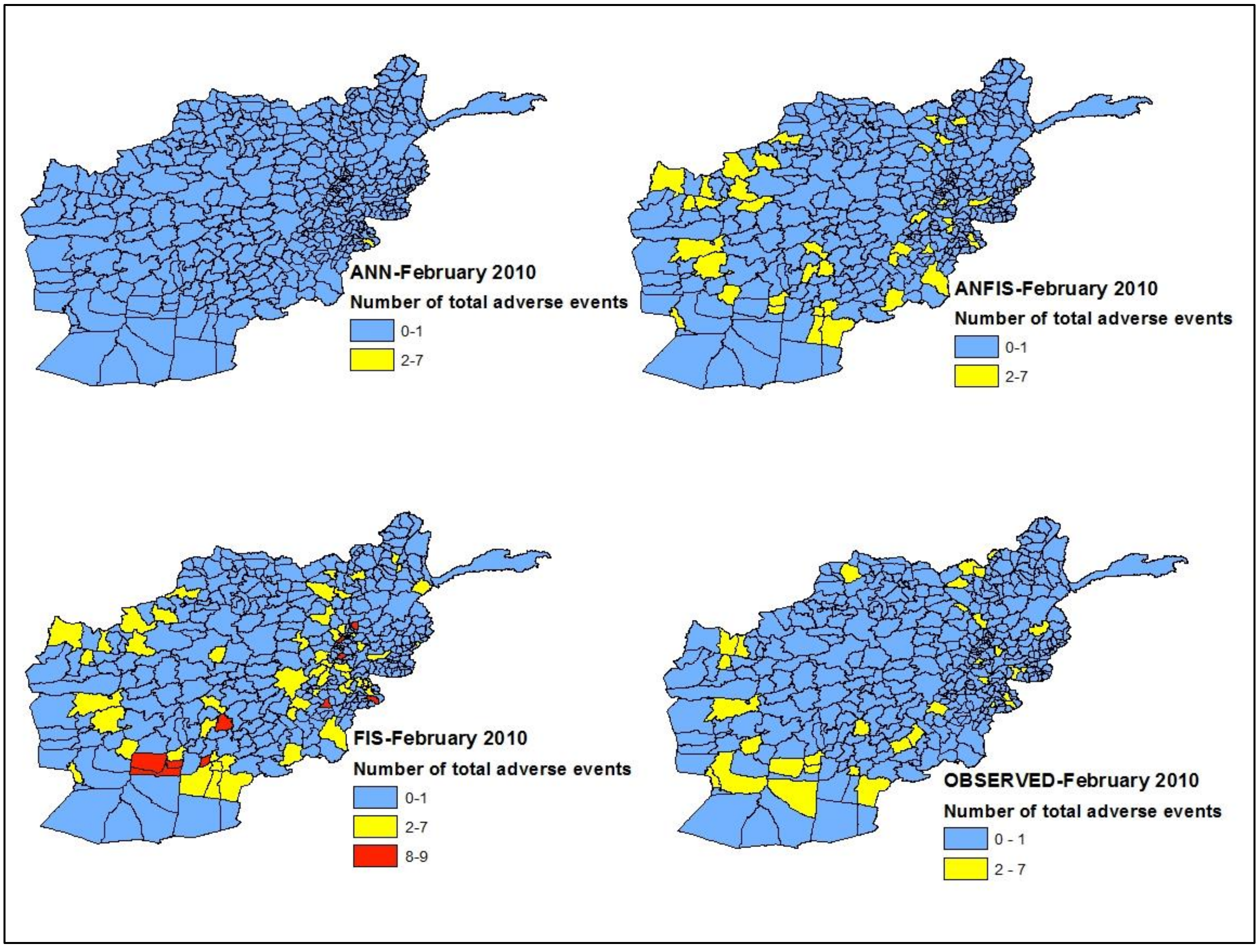


Figure 115: Predicted and observed values of number of total adverse events for each district in February 2010

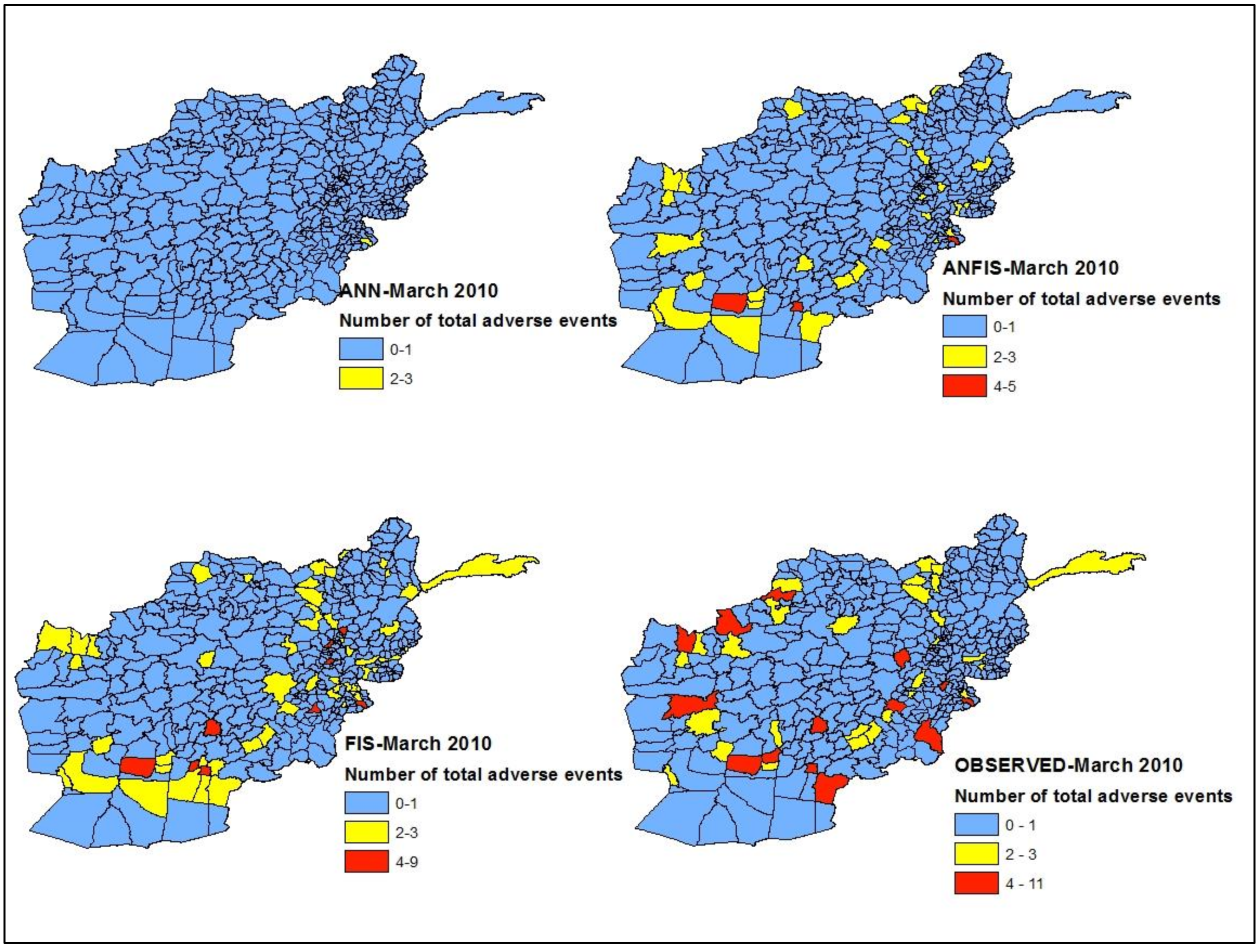


Figure 116: Predicted and observed values of number of total adverse events for each district in March 2010

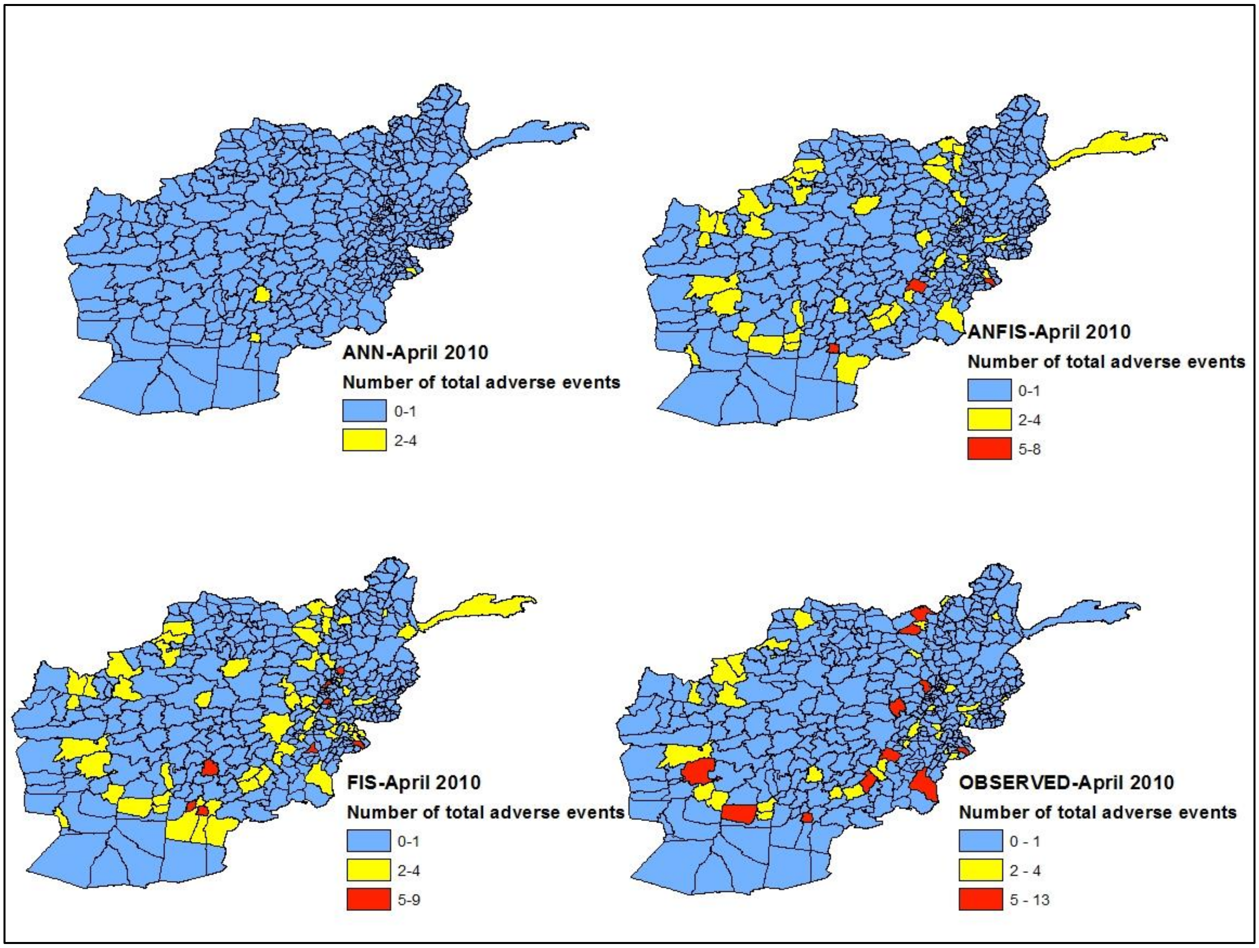


Figure 117: Predicted and observed values of number of total adverse events for each district in April 2010

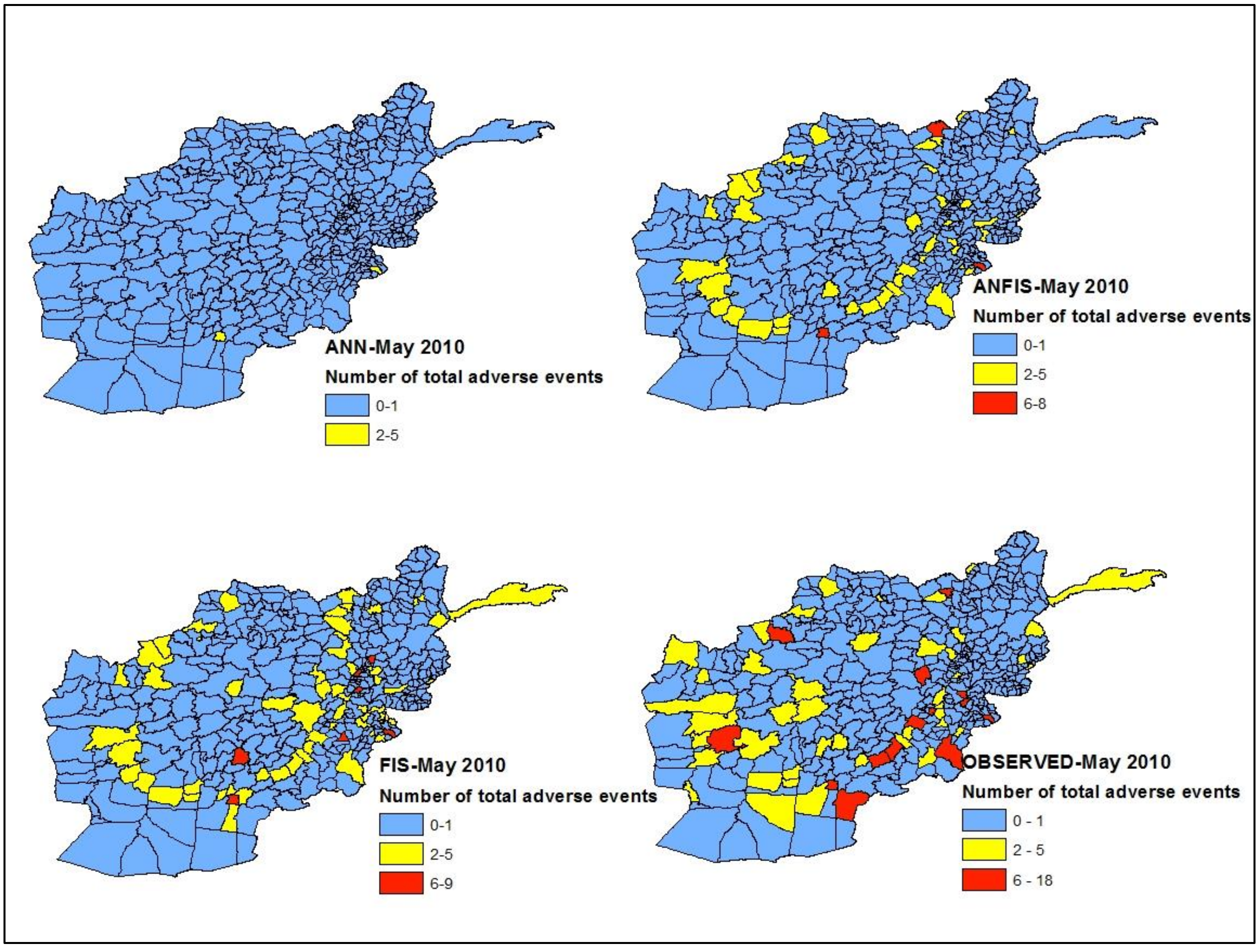


Figure 118: Predicted and observed values of number of total adverse events for each district in May 2010

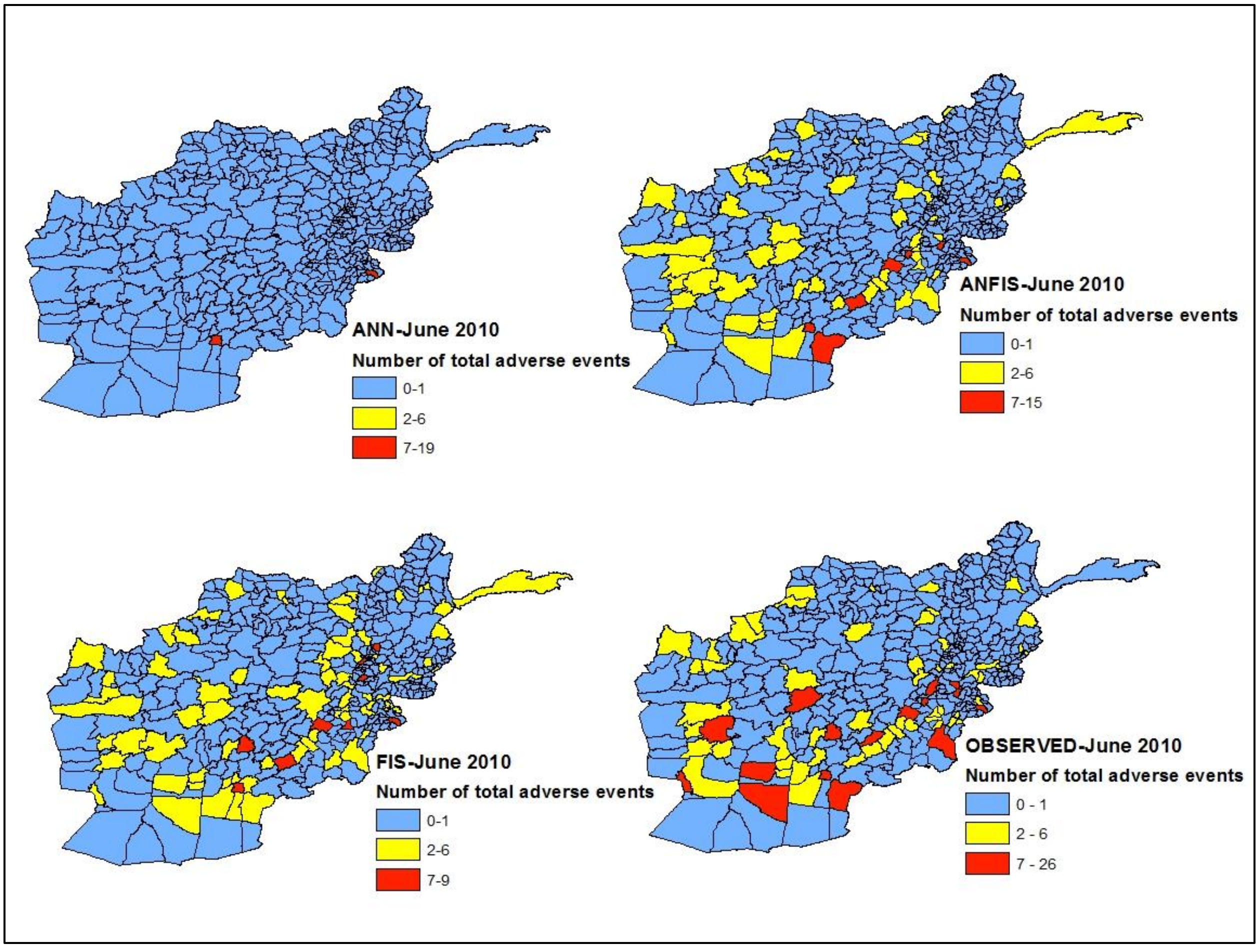


Figure 119: Predicted and observed values of number of total adverse events for each district in June 2010

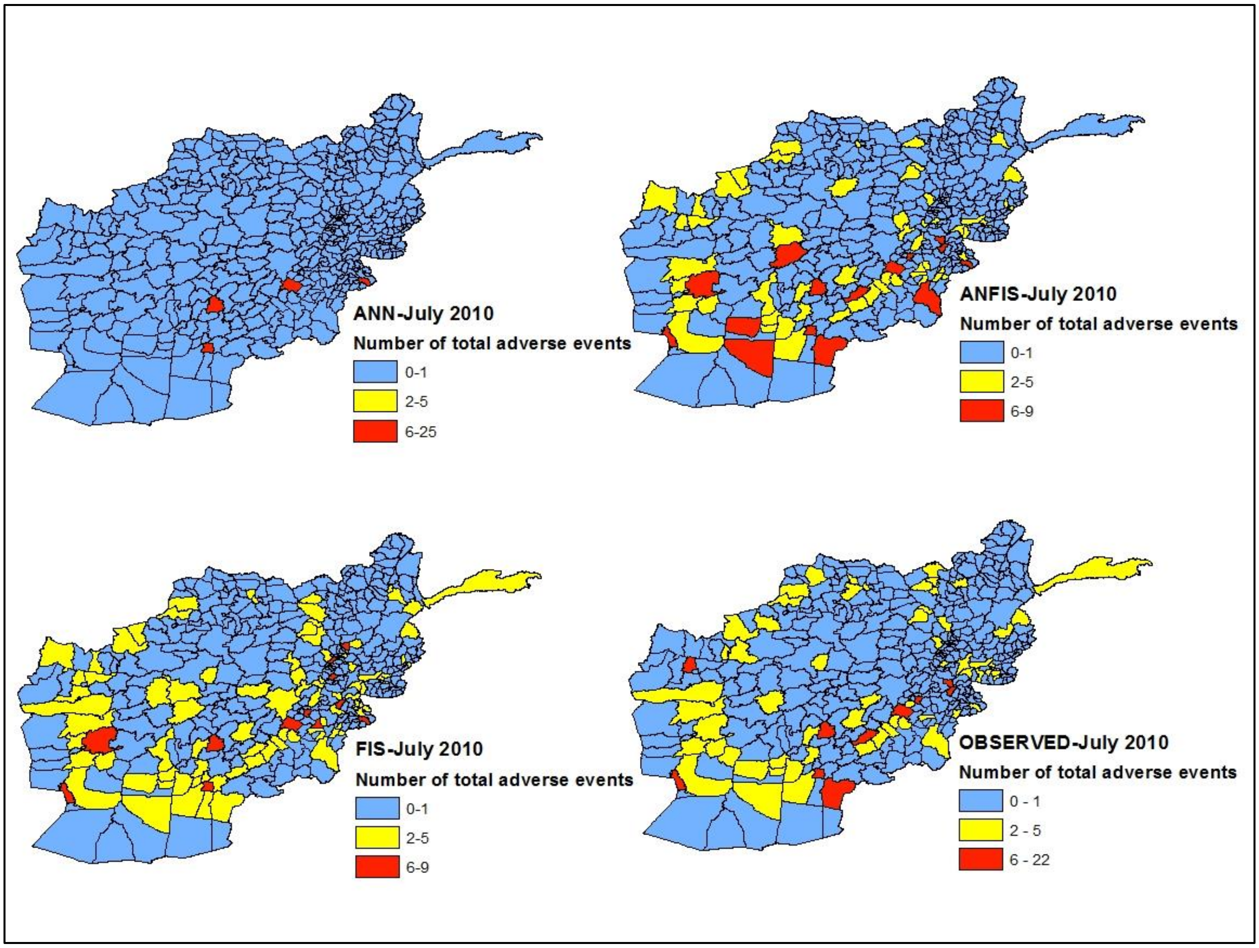


Figure 120: Predicted and observed values of number of total adverse events for each district in July 2010

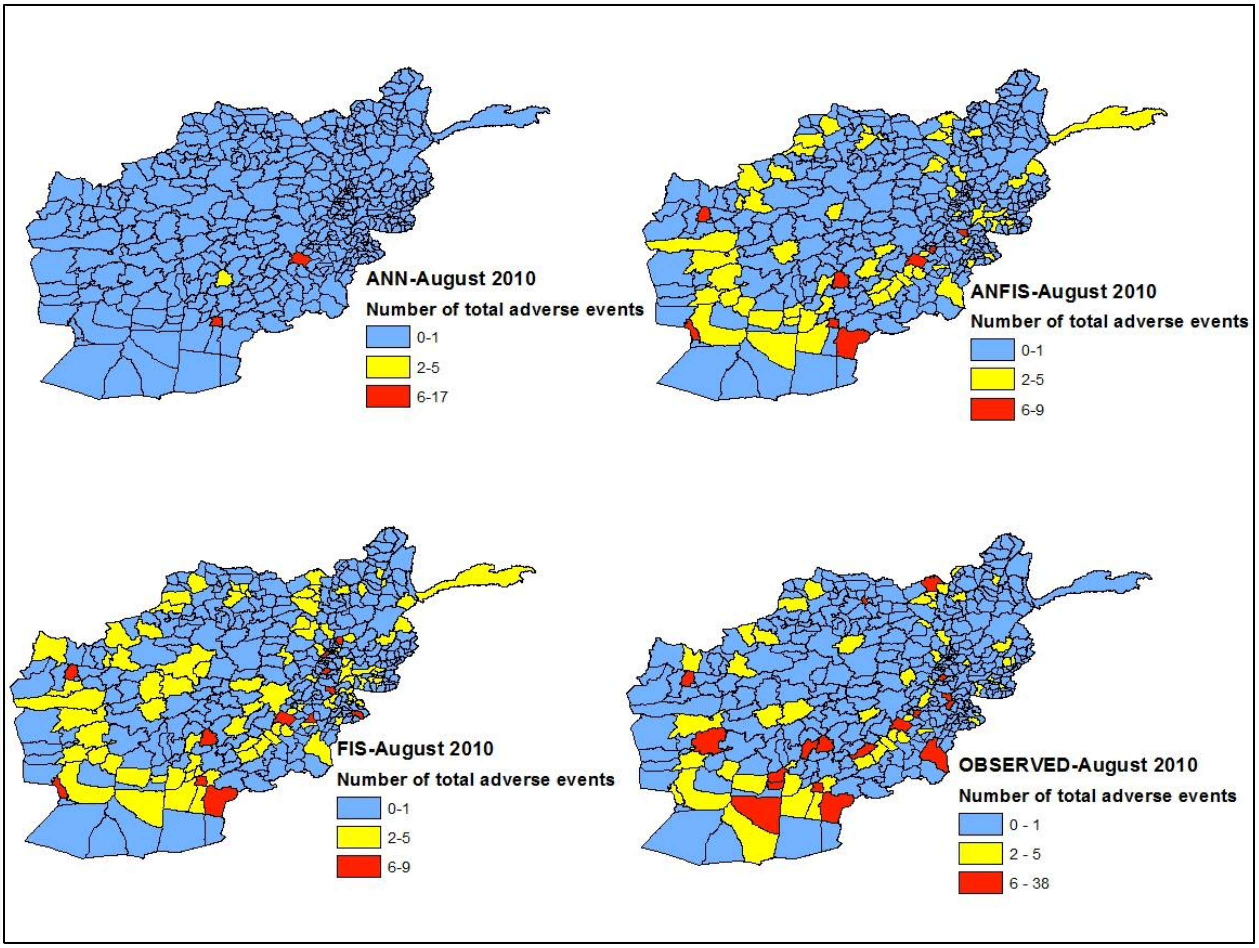


Figure 121: Predicted and observed values of number of total adverse events for each district in August 2010

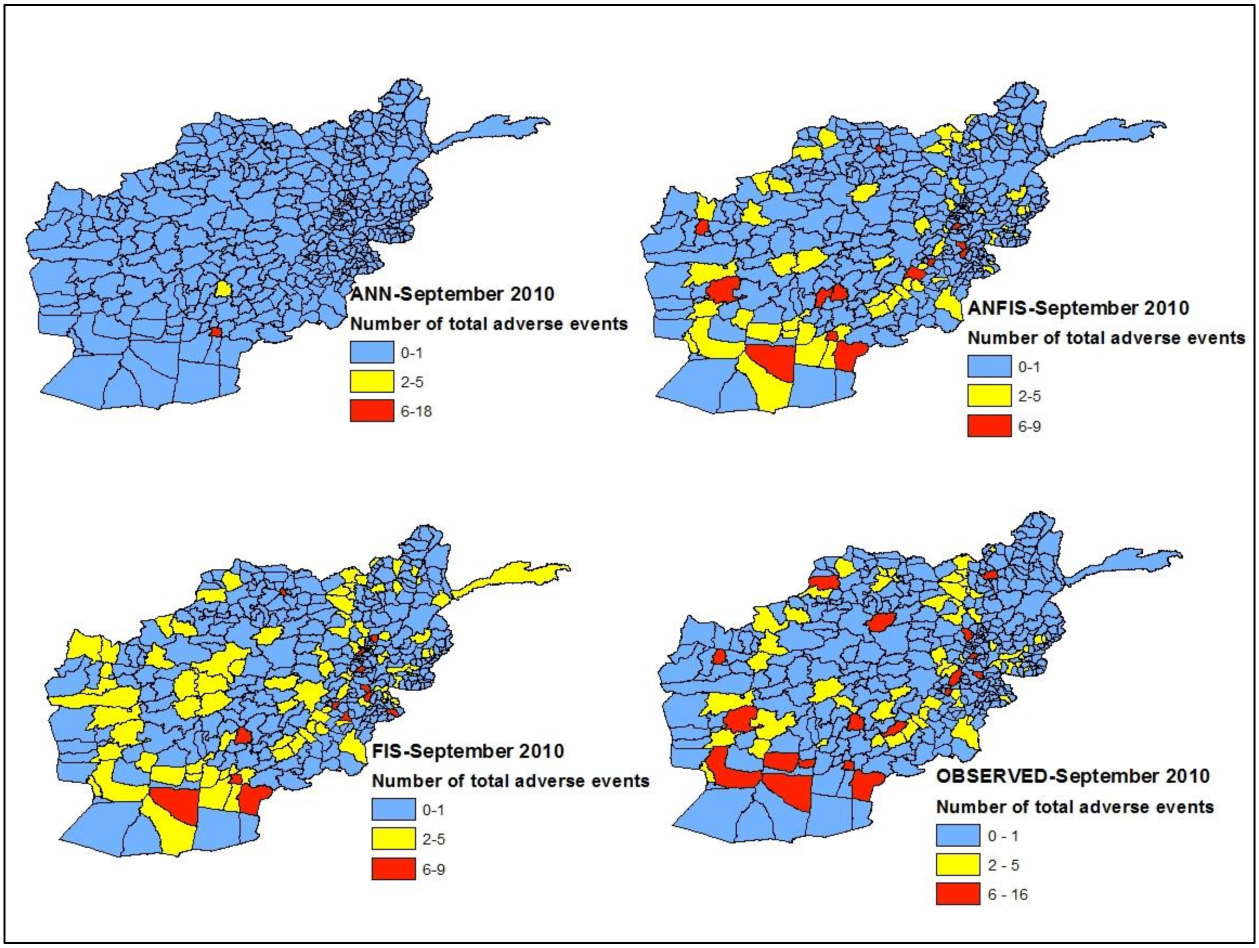


Figure 122: Predicted and observed values of number of total adverse events for each district in September 2010

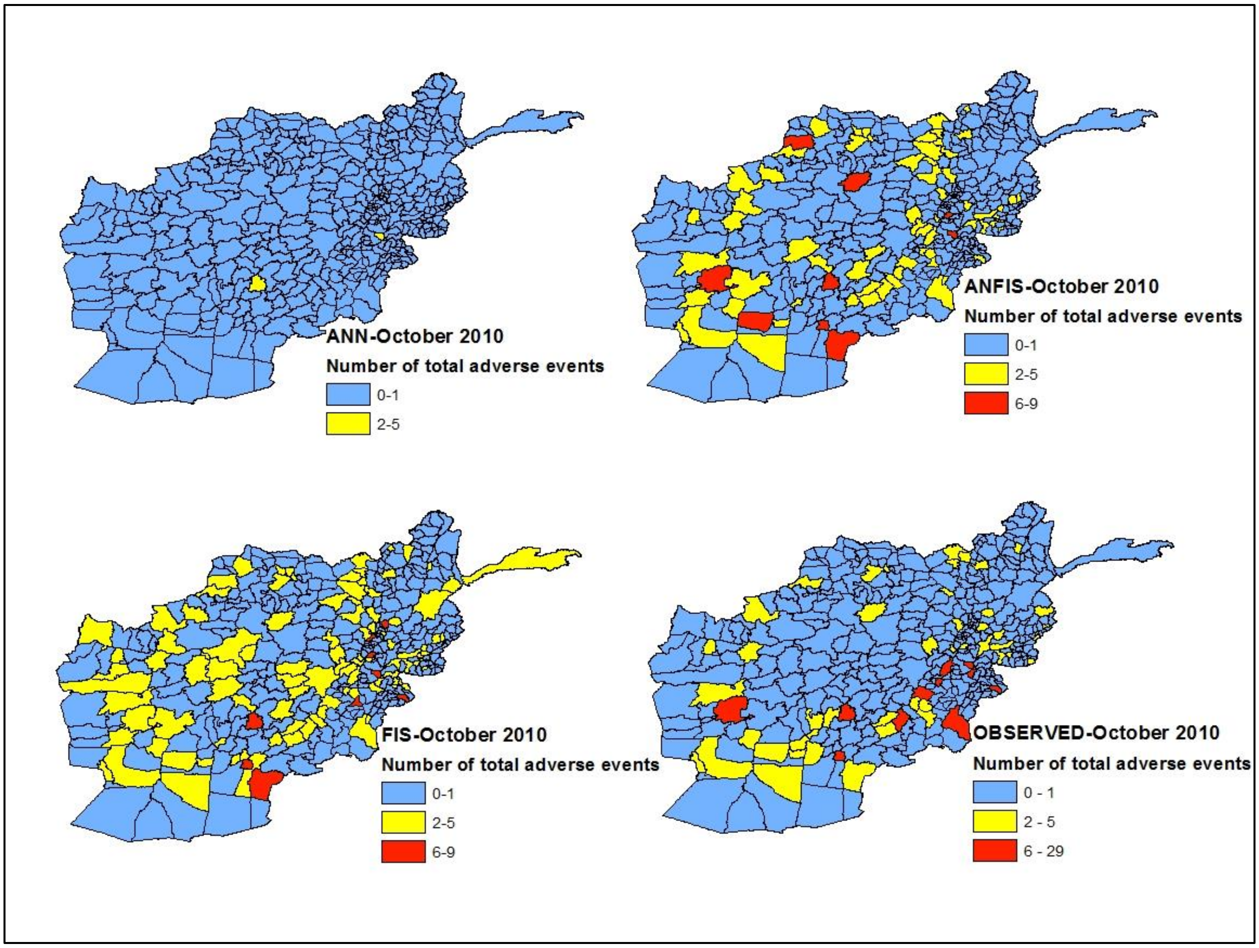


Figure 123: Predicted and observed values of number of total adverse events for each district in October 2010

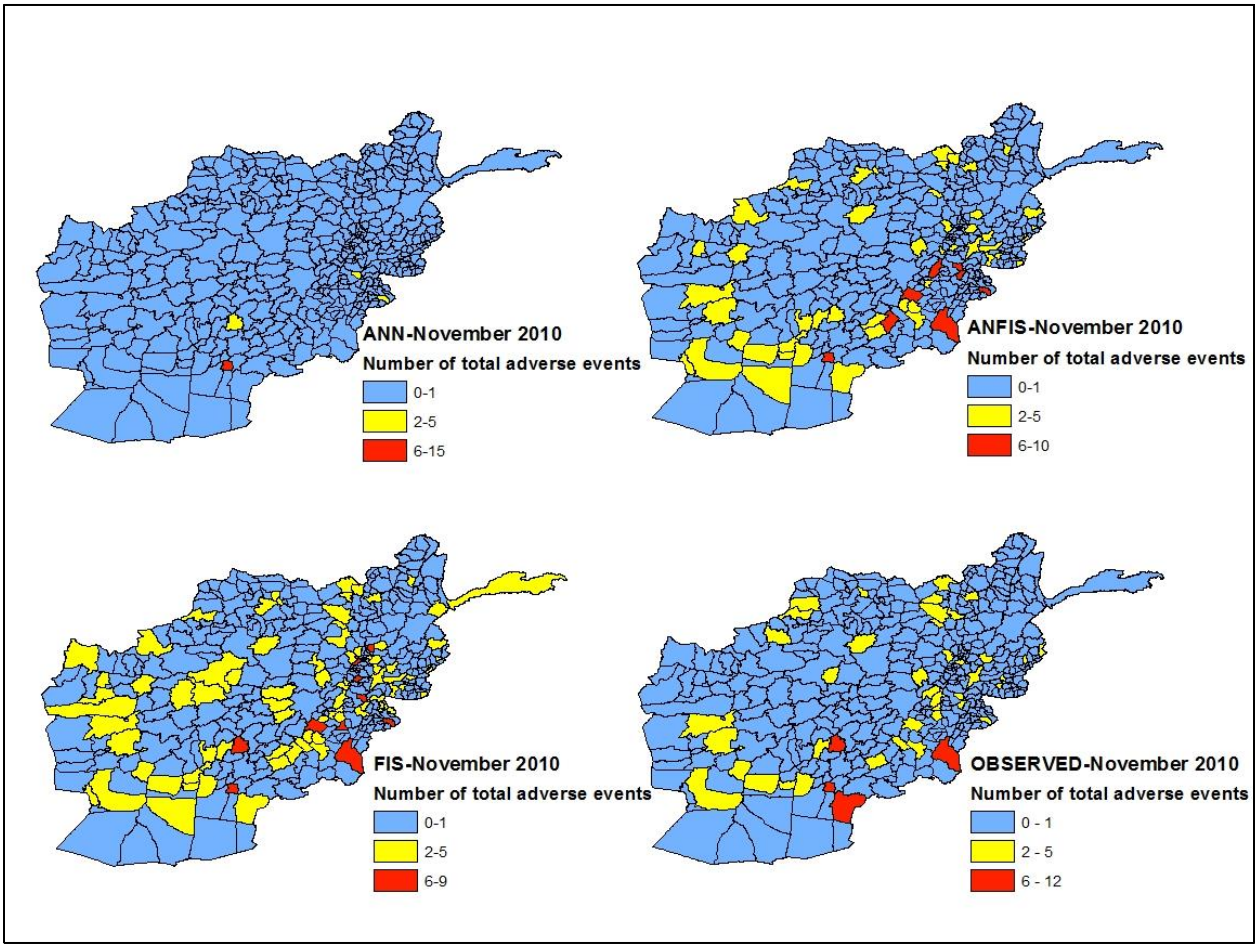


Figure 124: Predicted and observed values of number of total adverse events for each district in November 2010

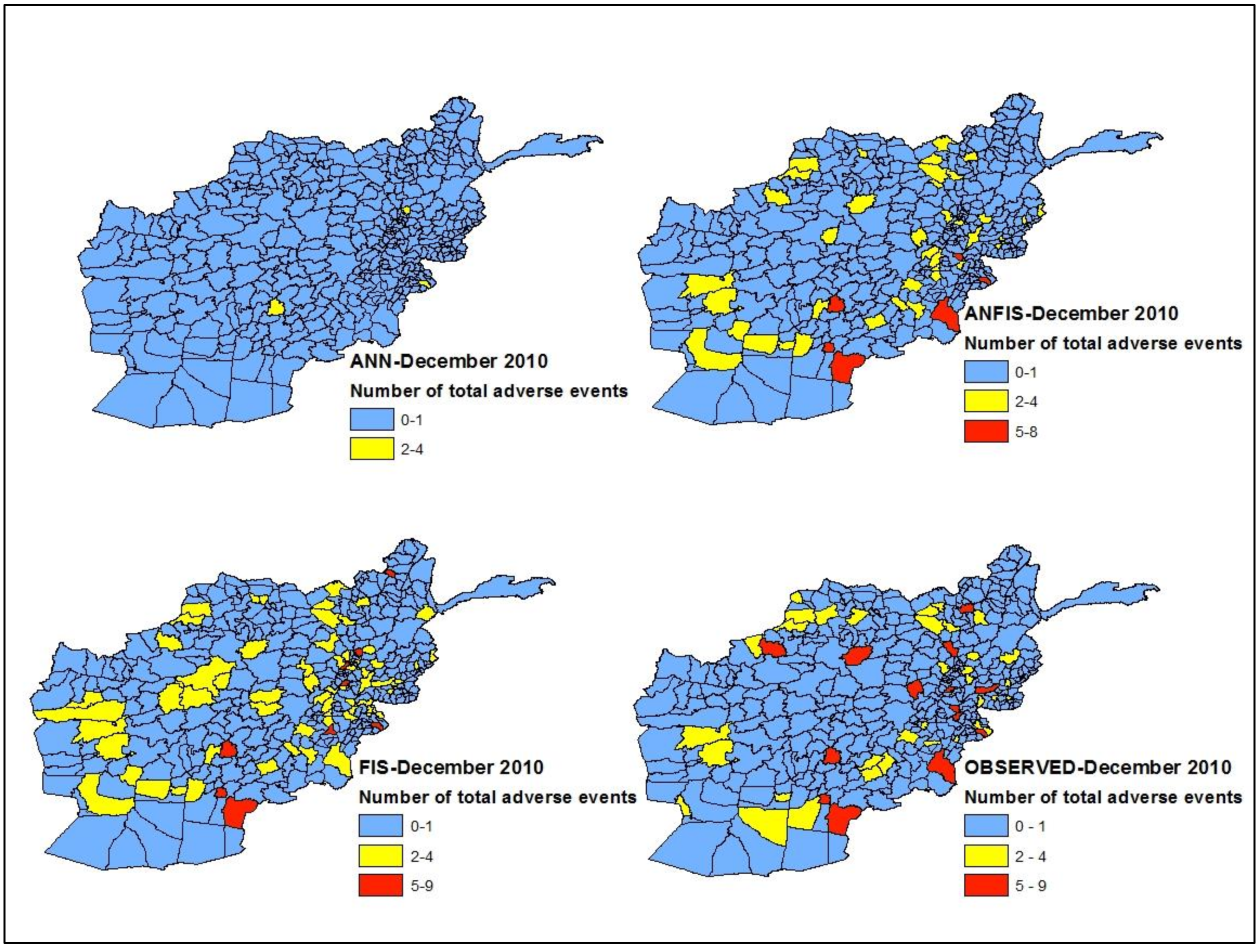


Figure 125: Predicted and observed values of number of total adverse events for each district in December 2010

APPENDIX E: MONTHLY MAE AND PERCENTAGE VALUES

Table 54: Monthly MAE and percentage values of number of people killed in Entire Afghanistan

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.4600	2.7051	0.5118	92.00	83.50	90.50
February	0.3863	2.3418	0.5224	95.75	85.00	92.75
March	0.6112	2.0043	0.7014	92.50	84.75	91.25
April	0.4642	1.9805	0.5969	92.25	85.00	90.50
May	0.7112	1.9419	0.7776	88.75	80.50	86.00
June	1.0401	2.2944	1.0826	86.00	78.75	83.75
July	0.8720	2.2595	0.8885	86.75	78.00	84.50
August	1.0557	2.4453	1.0778	86.50	76.75	82.50
September	0.5718	2.0928	0.6727	88.00	77.50	82.50
October	0.7861	2.1641	0.8416	88.75	81.00	86.50
November	0.5309	1.8814	0.6807	92.75	82.50	87.50
December	0.5092	2.0126	0.5561	91.25	84.00	89.25

Table 55: Monthly MAE and percentage values of number of people wounded in Entire Afghanistan

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.6274	5.1800	0.8464	92.75	73.50	89.25
February	0.6923	5.2705	0.9302	94.00	72.75	88.00
March	0.8383	4.0252	1.1063	91.25	78.00	86.00
April	1.0313	4.2340	1.1543	86.75	69.75	81.25
May	1.0749	3.7985	1.2222	88.25	68.25	79.25
June	1.3795	4.2914	1.5819	87.25	77.25	78.50
July	1.2013	4.2578	1.2901	87.50	74.00	81.50
August	1.6715	4.0634	1.7244	85.75	73.25	78.50
September	1.0517	4.3331	1.3644	88.50	76.75	80.00
October	0.9102	3.9417	1.1978	90.00	78.50	82.50
November	0.8382	3.8819	1.1152	89.25	77.50	81.50
December	0.7657	4.4108	1.0590	89.25	78.75	82.50

Table 56: Monthly MAE and percentage values of number of people hijacked in Entire Afghanistan

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.1250	0.3689	0.1694	97.75	92.75	97.75
February	0.0750	0.3152	0.1199	98.50	94.50	98.25
March	0.1025	0.2987	0.1365	98.00	95.75	97.75
April	0.1075	0.3053	0.1426	98.00	94.50	98.00
May	0.1875	0.3797	0.2218	96.75	93.75	96.50
June	0.2075	0.3687	0.2244	94.75	92.00	94.75
July	0.3800	0.5619	0.4131	94.50	91.50	94.50
August	0.1550	0.7806	0.2100	97.00	92.00	96.00
September	0.4000	0.5773	0.4284	95.50	93.25	95.25
October	0.1350	0.9215	0.2015	97.25	93.25	96.25
November	0.2100	0.5058	0.2280	95.75	93.50	95.75
December	0.2925	0.6782	0.3291	96.00	92.00	95.00

Table 57: Monthly MAE and percentage values of total number of adverse events in Entire Afghanistan

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.3882	0.8365	0.4045	90.50	83.25	90.25
February	0.3082	0.8028	0.3532	91.75	84.00	90.00
March	0.4773	0.8553	0.4515	89.25	83.00	88.75
April	0.5160	0.8083	0.4388	89.00	84.25	89.00
May	0.7312	0.9742	0.6432	85.50	80.00	85.50
June	1.0040	1.1448	0.8111	82.00	75.25	81.00
July	0.7872	1.0261	0.7084	82.25	75.75	81.75
August	0.9160	1.1013	0.7562	83.00	76.75	83.25
September	0.8729	0.9675	0.6387	80.75	76.25	82.25
October	0.7694	0.9860	0.6510	85.25	77.25	84.00
November	0.5132	0.8542	0.5410	88.75	80.00	86.25
December	0.6207	0.8658	0.5613	87.00	80.00	85.25

Table 58: Monthly MAE and percentage values of number of people killed in Eastern region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.2757	0.6051	0.3672	92.00	90.00	92.00
February	0.4000	0.7885	0.4980	96.00	92.00	96.00
March	0.0600	0.8090	0.1672	98.00	92.00	98.00
April	0.2200	0.5814	0.3206	96.00	94.00	96.00
May	0.2400	0.7484	0.3263	92.00	90.00	92.00
June	0.2800	0.8857	0.3746	92.00	90.00	92.00
July	0.4000	0.9345	0.4879	90.00	88.00	90.00
August	0.4200	1.0158	0.5107	92.00	90.00	92.00
September	0.3400	0.6501	0.4091	90.00	88.00	90.00
October	0.3400	0.7144	0.4241	94.00	92.00	94.00
November	0.2200	0.6365	0.3132	94.00	96.00	94.00
December	0.2000	0.5801	0.2953	94.00	92.00	94.00

Table 59: Monthly MAE and percentage values of number of people wounded in Eastern region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	1.040	1.4422	1.3977	94.00	80.00	92.00
February	0.580	3.4573	0.9433	92.00	76.00	90.00
March	0.340	0.7409	0.6279	88.00	62.00	88.00
April	0.968	1.1146	1.2141	82.00	78.00	82.00
May	0.735	3.3558	1.0342	88.00	72.00	88.00
June	1.475	3.1219	1.7690	84.00	76.00	84.00
July	1.280	3.5826	1.5979	82.00	70.00	82.00
August	1.120	3.4390	1.4934	82.00	70.00	82.00
September	1.520	3.2239	1.7863	88.00	72.00	88.00
October	0.322	3.2998	0.7107	94.00	78.00	94.00
November	1.340	1.6893	1.6417	90.00	80.00	90.00
December	0.672	3.7016	0.9079	84.00	52.00	84.00

Table 60: Monthly MAE and percentage values of number of people hijacked in Eastern region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.300	0.3452	0.300	94.00	94.00	94.00
February	0.080	0.1560	0.080	96.00	96.00	96.00
March	0.080	0.1524	0.080	98.00	96.00	98.00
April	0.220	0.3095	0.220	96.00	94.00	96.00
May	0.480	0.7218	0.480	94.00	92.00	94.00
June	0.180	0.5453	0.180	94.00	90.00	94.00
July	0.280	0.4484	0.280	92.00	92.00	92.00
August	0.500	0.7535	0.500	92.00	88.00	92.00
September	0.160	0.4376	0.160	96.00	94.00	96.00
October	0.160	0.2224	0.160	94.00	94.00	94.00
November	0.460	0.5573	0.460	90.00	88.00	90.00
December	0.540	0.6452	0.540	94.00	94.00	94.00

Table 61: Monthly MAE and percentage values of total number of adverse events in Eastern region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.4018	0.6013	0.4571	94.00	92.00	94.00
February	0.2487	0.5585	0.3087	94.00	92.00	94.00
March	0.3229	0.5806	0.4174	96.00	96.00	94.00
April	0.4531	0.5562	0.4677	92.00	94.00	92.00
May	0.4131	0.6137	0.4633	92.00	92.00	92.00
June	0.7077	0.9268	0.7713	84.00	84.00	84.00
July	1.0563	1.0024	0.9875	80.00	80.00	80.00
August	0.6051	0.6922	0.5984	86.00	84.00	86.00
September	0.8060	0.8493	0.8627	78.00	78.00	78.00
October	0.6285	0.7895	0.6392	80.00	80.00	82.00
November	0.5260	0.7513	0.6008	88.00	78.00	88.00
December	0.6086	0.6809	0.6214	88.00	86.00	86.00

Table 62: Monthly MAE and percentage values of number of people killed in Central region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.3273	0.9864	0.6142	92.7273	87.2727	92.7273
February	0.4909	1.2665	0.2337	98.1818	87.2727	98.1818
March	0.1818	1.3593	0.4691	94.5455	83.6364	92.7273
April	0.2727	1.0253	0.4147	92.7273	81.8182	92.7273
May	0.6182	1.2624	0.5827	92.7273	81.8182	92.7273
June	0.5636	1.6056	0.7404	90.9091	80.0000	89.0909
July	0.5273	1.1252	0.5682	92.7273	85.4545	92.7273
August	0.5273	1.2099	0.4819	92.7273	83.6364	94.5455
September	0.6727	1.2754	0.8043	90.9091	81.8182	89.0909
October	0.3636	0.9917	0.5611	90.9091	83.6364	89.0909
November	0.1636	0.9485	0.3100	98.1818	87.2727	96.3636
December	0.2000	0.8230	0.3244	94.5455	87.2727	94.5455

Table 63: Monthly MAE and percentage values of number of people wounded in Central region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	1.6546	4.080	1.4852	94.5455	85.4545	92.7273
February	0.9636	4.769	0.7940	94.5455	83.6364	92.7273
March	0.1818	5.533	0.7015	94.5455	83.6364	92.7273
April	0.5455	5.695	1.0080	87.2727	80.0000	85.4545
May	1.3818	5.019	1.1983	90.9091	74.5455	89.0909
June	0.3819	5.769	0.9237	92.7273	80.0000	89.0909
July	1.0547	4.782	0.8849	92.7273	81.8182	90.9091
August	2.8365	4.963	2.6529	90.9091	83.6364	89.0909
September	0.6546	5.853	1.1466	92.7273	52.7273	89.0909
October	0.5636	4.337	1.0623	90.9091	49.0909	87.2727
November	0.1455	4.290	0.6946	94.5455	47.2727	90.9091
December	0.2364	4.121	0.6626	94.5455	50.9091	92.7273

Table 64: Monthly MAE and percentage values of number of people hijacked in Central region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.0182	0.3335	0.1017	100.00	92.7273	96.3636
February	0.0545	0.3042	0.1271	98.18	94.5455	94.5455
March	0.0909	0.3585	0.1564	98.18	92.7273	96.3636
April	0.0182	0.2769	0.1014	100.00	94.5455	96.3636
May	0.0545	0.2908	0.1015	98.18	94.5455	96.3636
June	0.2545	0.4849	0.2866	94.55	89.0909	92.7273
July	0.1814	0.4158	0.2222	96.36	90.9091	94.5455
August	0.0182	0.3963	0.0705	100.00	92.7273	98.1818
September	0.2000	0.4239	0.2377	96.36	92.7273	94.5455
October	0.0000	0.4127	0.0883	100.00	92.7273	96.3636
November	0.3091	0.5291	0.3454	94.55	90.9091	94.5455
December	0.1091	0.5513	0.1933	94.55	85.4545	90.9091

Table 65: Monthly MAE and percentage values of total number of adverse events in Central region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.2367	0.8000	0.2212	94.5455	85.4545	96.3636
February	0.1430	0.8309	0.2170	94.5455	85.4545	94.5455
March	0.3093	0.9025	0.3524	94.5455	85.4545	92.7273
April	0.4202	0.9779	0.3933	90.9091	80.0000	87.2727
May	0.4918	0.9665	0.3890	90.9091	83.6364	94.5455
June	0.6000	1.1254	0.5055	87.2727	78.1818	89.0909
July	0.4192	1.0170	0.4396	92.7273	78.1818	87.2727
August	0.5465	1.1199	0.4999	87.2727	74.5455	85.4545
September	0.9507	1.2754	0.6156	83.6364	72.7273	85.4545
October	0.6701	1.1963	0.5607	83.6364	74.5455	80.0000
November	0.6345	1.0186	0.4916	87.2727	78.1818	85.4545
December	0.5670	1.1036	0.5815	87.2727	70.9091	81.8182

Table 66: Monthly MAE and percentage values of number of people killed in North Eastern region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.075	0.240	0.083	100.00	98.51	100.00
February	0.004	0.187	0.074	100.00	100.00	98.51
March	0.387	0.520	0.425	95.52	95.52	94.03
April	0.148	0.434	0.192	97.01	94.03	95.52
May	0.330	0.562	0.392	94.03	91.04	92.54
June	0.281	0.441	0.317	92.54	89.55	91.04
July	0.624	0.830	0.635	89.55	86.57	89.55
August	0.801	0.791	0.806	92.54	89.55	92.54
September	0.520	0.655	0.518	89.55	86.57	91.04
October	0.479	0.733	0.538	94.03	86.57	92.54
November	0.629	1.037	0.649	91.04	86.57	92.54
December	0.297	1.111	0.326	91.04	88.06	89.55

Table 67: Monthly MAE and percentage values of number of people wounded in North Eastern region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.1045	0.4416	0.1702	98.5075	95.5224	97.0149
February	0.1642	0.4678	0.2735	95.5224	92.5373	92.5373
March	0.2537	0.4955	0.3309	95.5224	92.5373	94.0299
April	1.2836	1.7055	1.2832	91.0448	88.0597	92.5373
May	0.6866	0.8529	0.7434	92.5373	88.0597	91.0448
June	0.1493	0.5717	0.1544	95.5224	97.0149	98.5075
July	1.0299	1.2056	1.0259	91.0448	91.0448	91.0448
August	1.0434	1.7676	1.0081	88.0597	86.5672	88.0597
September	0.4926	1.1310	0.4839	91.0448	83.5821	91.0448
October	0.7762	1.2926	0.8733	94.0299	86.5672	91.0448
November	0.7612	1.0612	0.7904	89.5522	85.0746	89.5522
December	0.4037	1.5391	0.4448	92.5373	85.0746	91.0448

Table 68: Monthly MAE and percentage values of number of people hijacked in North Eastern region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.060	0.191	0.123	98.507	95.522	95.522
February	0.030	0.104	0.062	98.507	97.015	97.015
March	0.015	0.076	0.029	100.000	98.507	100.000
April	0.388	0.408	0.392	92.537	92.537	92.537
May	0.045	0.269	0.139	98.507	94.030	95.522
June	0.045	0.109	0.059	98.507	97.015	98.507
July	0.090	0.157	0.105	98.507	97.015	98.507
August	0.060	0.148	0.063	100.000	98.507	100.000
September	0.507	0.643	0.518	97.015	95.522	97.015
October	0.015	0.155	0.142	100.000	97.015	97.015
November	0.030	0.080	0.037	98.507	98.507	98.507
December	0.358	0.487	0.373	97.015	94.030	97.015

Table 69: Monthly MAE and percentage values of total number of adverse events in North Eastern region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.2505	0.4255	0.3075	92.5373	89.5522	92.5373
February	0.3109	0.4728	0.3507	89.5522	86.5672	88.0597
March	0.3398	0.3354	0.3203	88.0597	89.5522	92.5373
April	0.4349	0.5622	0.4881	89.5522	86.5672	88.0597
May	0.2824	0.5190	0.2933	91.0448	89.5522	92.5373
June	0.3101	0.3185	0.3002	92.5373	91.0448	92.5373
July	0.4427	0.4189	0.4079	88.0597	88.0597	88.0597
August	0.5488	0.4514	0.4279	85.0746	88.0597	86.5672
September	0.5844	0.6157	0.4886	85.0746	91.0448	88.0597
October	0.3146	0.5064	0.3326	91.0448	91.0448	89.5522
November	0.3026	0.4924	0.3020	91.0448	89.5522	88.0597
December	0.4308	0.6741	0.4510	91.0448	89.5522	89.5522

Table 70: Monthly MAE and percentage values of number of people killed in North Western

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.1091	0.3185	0.1407	98.1818	96.3636	98.1818
February	0.0545	0.2920	0.0910	100.0000	100.0000	100.0000
March	0.0727	0.2916	0.1044	98.1818	98.1818	98.1818
April	0.1273	0.3548	0.1567	98.1818	96.3636	98.1818
May	0.2545	0.4129	0.2768	94.5455	94.5455	94.5455
June	0.1091	0.3196	0.1354	96.3636	94.5455	96.3636
July	0.0727	0.2670	0.1088	98.1818	96.3636	98.1818
August	0.3273	0.5619	0.3568	92.7273	90.9091	92.7273
September	0.4545	0.6417	0.4751	89.0909	90.9091	89.0909
October	0.2909	0.5341	0.3504	96.3636	90.9091	94.5455
November	0.2727	0.5637	0.3150	98.1818	94.5455	98.1818
December	0.4545	0.7449	0.4270	89.0909	85.4545	90.9091

Table 71: Monthly MAE and percentage values of number of people wounded in North Western region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.0727	0.2831	0.1182	96.3636	98.1818	96.3636
February	0.1818	0.4329	0.2372	96.3636	92.7273	96.3636
March	0.1455	0.3955	0.2012	98.1818	94.5455	98.1818
April	0.4545	0.6892	0.4897	94.5455	92.7273	94.5455
May	0.2000	0.3509	0.2517	92.7273	92.7273	92.7273
June	0.0182	0.3341	0.0786	100.0000	92.7273	100.0000
July	0.1455	0.3226	0.1797	96.3636	96.3636	96.3636
August	0.4182	0.5055	0.4738	92.7273	92.7273	92.7273
September	0.7818	0.8771	0.8151	92.7273	90.9091	92.7273
October	0.2546	0.3373	0.3043	96.3636	96.3636	96.3636
November	1.0364	1.1139	1.0848	89.0909	89.0909	89.0909
December	0.8909	1.1903	0.9193	89.0909	85.4545	89.0909

Table 72: Monthly MAE and percentage values of number of people hijacked in North Western region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.1273	0.2323	0.1281	98.1818	98.1818	98.1818
February	0.0909	0.2836	0.0962	98.1818	96.3636	98.1818
March	0.1455	0.2508	0.1481	98.1818	98.1818	98.1818
April	0.0182	0.2218	0.0254	100.0000	98.1818	100.0000
May	0.0909	0.1986	0.0936	98.1818	98.1818	98.1818
June	0.2727	0.3866	0.2789	92.7273	90.9091	92.7273
July	0.4545	0.5402	0.4432	90.9091	90.9091	90.9091
August	0.1091	0.4363	0.1247	98.1818	89.0909	98.1818
September	0.3455	0.4335	0.3498	92.7273	90.9091	92.7273
October	0.1636	0.3099	0.1646	94.5455	90.9091	94.5455
November	0.2909	0.3815	0.2973	94.5455	90.9091	94.5455
December	0.4545	0.6450	0.4439	92.7273	89.0909	92.7273

Table 73: Monthly MAE and percentage values of total number of adverse events in North Western region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.1818	0.4121	0.2204	96.3636	94.5455	94.5455
February	0.2364	0.4143	0.2669	98.1818	94.5455	96.3636
March	0.3273	0.4516	0.3057	92.7273	92.7273	92.7273
April	0.2909	0.4255	0.2696	92.7273	92.7273	92.7273
May	0.5455	0.7043	1.5794	90.9091	87.2727	89.0909
June	0.3273	0.5125	0.3462	90.9091	89.0909	87.2727
July	0.4545	0.5475	0.3949	87.2727	87.2727	87.2727
August	0.5455	0.6298	0.4685	90.9091	89.0909	92.7273
September	0.7273	0.7243	0.6366	80.0000	85.4545	81.8182
October	0.3455	0.4162	0.2690	92.7273	92.7273	90.9091
November	0.4364	0.5217	0.4048	90.9091	90.9091	90.9091
December	0.7455	0.6749	0.6474	85.4545	87.2727	85.4545

Table 74: Monthly MAE and percentage values of number of people killed in South Eastern

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.5320	1.2927	0.6711	90.3226	87.0968	87.0968
February	0.2606	1.1755	0.3699	95.1613	88.7097	91.9355
March	0.6298	1.4107	0.8197	87.0968	85.4839	85.4839
April	0.6399	1.2938	0.7583	90.3226	87.0968	85.4839
May	1.1033	1.6994	1.1863	90.3226	82.2581	83.8710
June	1.3116	1.7766	1.2134	82.2581	79.0323	82.2581
July	1.4296	1.7804	1.2476	82.2581	77.4194	80.6452
August	1.0746	1.8229	1.1888	80.6452	70.9677	74.1935
September	0.3856	1.5141	0.9420	91.9355	80.6452	79.0323
October	1.1347	1.8324	1.2590	85.4839	80.6452	82.2581
November	0.6447	1.2348	1.0234	91.9355	88.7097	83.8710
December	0.4603	1.1715	0.5352	91.9355	90.3226	91.9355

Table 75: Monthly MAE and percentage values of number of people wounded in South Eastern region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.6860	1.7782	0.8294	87.0968	75.8065	83.8710
February	0.2131	1.8450	0.6433	95.1613	69.3548	87.0968
March	0.8832	1.8663	0.8533	85.4839	67.7419	83.8710
April	0.6816	1.9362	1.0364	85.4839	67.7419	79.0323
May	1.6399	2.4139	1.9378	80.6452	61.2903	77.4194
June	2.3481	3.4610	2.6047	85.4839	64.5161	75.8065
July	0.8061	2.2841	1.0699	88.7097	66.1290	82.2581
August	1.7735	2.8601	1.8891	88.7097	70.9677	85.4839
September	1.4907	2.8082	1.6738	83.8710	80.6452	80.6452
October	1.3776	2.6147	1.3382	87.0968	80.6452	79.0323
November	0.6899	1.8093	1.2342	90.3226	79.0323	79.0323
December	0.8720	2.7623	1.3786	90.3226	80.6452	83.8710

Table 76: Monthly MAE and percentage values of number of people hijacked in South Eastern region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	7.9E-13	0.4383	0.1278	100.000	91.9355	93.5484
February	1.6E-02	0.4143	0.1026	100.000	95.1613	96.7742
March	5.8E-14	0.3731	0.0973	100.000	95.1613	96.7742
April	4.8E-02	0.4145	0.1348	98.387	93.5484	95.1613
May	2.7E-01	0.5695	0.3417	93.548	90.3226	91.9355
June	2.6E-01	0.5073	0.3181	93.548	90.3226	90.3226
July	9.0E-01	1.3469	1.1147	96.774	87.0968	87.0968
August	8.1E-02	1.0847	0.4068	98.387	90.3226	91.9355
September	3.7E-01	0.7685	0.4923	96.774	90.3226	91.9355
October	1.6E-02	0.7403	0.2395	100.000	91.9355	93.5484
November	4.8E-02	0.3529	0.1086	98.387	96.7742	96.7742
December	4.0E-01	0.7223	0.4697	96.774	91.9355	93.5484

Table 77: Monthly MAE and percentage values of total number of adverse events in South Eastern region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.4934	0.7556	0.2846	90.3226	88.7097	95.1613
February	0.2467	0.8080	0.3122	93.5484	85.4839	91.9355
March	0.6133	1.1013	0.5079	87.0968	85.4839	88.7097
April	0.5908	0.9276	0.3522	83.8710	85.4839	88.7097
May	1.2157	1.4770	0.9963	82.2581	77.4194	79.0323
June	1.5859	1.8071	1.2422	75.8065	74.1935	75.8065
July	0.8528	1.3271	1.0547	80.6452	75.8065	74.1935
August	1.1091	1.3787	0.7422	80.6452	80.6452	83.8710
September	0.5718	1.0304	0.6946	83.8710	85.4839	79.0323
October	1.1251	1.4442	0.8919	87.0968	83.8710	87.0968
November	0.5719	1.0382	0.7277	87.0968	83.8710	83.8710
December	0.6488	1.0292	0.5682	85.4839	83.8710	82.2581

Table 78: Monthly MAE and percentage values of number of people killed in South Western

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	1.6316	2.6505	1.2939	83.3333	51.6667	76.6667
February	1.0773	2.6212	1.3395	85.0000	48.3333	75.0000
March	1.9815	2.3391	2.1716	81.6667	48.3333	75.0000
April	1.1184	2.4243	1.3773	81.6667	45.0000	73.3333
May	1.5241	2.7072	1.7470	75.0000	50.0000	68.3333
June	3.2016	4.1417	3.1902	63.3333	46.6667	65.0000
July	2.1476	3.6902	2.2251	66.6667	35.0000	58.3333
August	2.9186	3.3624	3.2373	73.3333	31.6667	58.3333
September	1.0445	3.3570	1.3752	78.3333	45.0000	66.6667
October	1.6379	2.2319	1.8071	76.6667	46.6667	71.6667
November	1.1282	2.6467	1.7237	80.0000	43.3333	61.6667
December	1.3399	2.3193	1.5104	85.0000	50.0000	73.3333

Table 79: Monthly MAE and percentage values of number of people wounded in South Western region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	1.4032	5.8422	1.2730	81.6667	55.0000	85.0000
February	2.2897	4.5068	2.5896	85.0000	50.0000	78.3333
March	1.7064	5.7022	3.2388	86.6667	51.6667	81.6667
April	1.1834	4.8653	2.6997	80.0000	45.0000	75.0000
May	2.3995	2.9068	1.7811	80.0000	50.0000	76.6667
June	4.6427	5.0918	4.3091	66.6667	45.0000	68.3333
July	2.9818	5.2799	2.9086	71.6667	38.3333	68.3333
August	3.4472	4.2458	3.1541	73.3333	46.6667	71.6667
September	1.4958	4.5676	1.5396	81.6667	46.6667	78.3333
October	2.1833	2.4025	2.3041	78.3333	50.0000	71.6667
November	1.3167	3.0113	1.5428	81.6667	45.0000	76.6667
December	1.9333	2.1447	2.0393	81.6667	50.0000	75.0000

Table 80: Monthly MAE and percentage values of number of people hijacked in South Western region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.0167	0.5111	0.0934	100.000	90.0000	100.000
February	0.0000	0.4857	0.0791	100.000	91.6667	100.000
March	0.1167	0.5207	0.1885	96.6667	91.6667	96.6667
April	0.0167	0.4542	0.0822	100.000	95.0000	100.000
May	0.0333	0.3844	0.1076	100.000	96.6667	100.000
June	0.0500	0.4160	0.1267	98.3333	95.0000	98.3333
July	0.3667	0.7094	0.4360	93.3333	88.3333	93.3333
August	0.1833	0.5899	0.2440	95.0000	91.6667	95.0000
September	0.8333	1.2726	0.9100	98.3333	93.3333	98.3333
October	0.1000	0.7833	0.1742	96.6667	91.6667	96.6667
November	0.0833	0.4969	0.1551	96.6667	91.6667	96.6667
December	0.0833	0.4869	0.1600	98.3333	95.0000	98.3333

Table 81: Monthly MAE and percentage values of total number of adverse events in South Western region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.6540	1.1289	0.5692	81.6667	78.3333	83.3333
February	0.6651	1.1427	0.6425	81.6667	80.0000	83.3333
March	0.7162	0.9972	0.6865	81.6667	78.3333	83.3333
April	0.6839	0.9605	0.6076	85.0000	86.6667	88.3333
May	1.1405	1.2903	0.9936	78.3333	81.6667	81.6667
June	1.7422	1.7164	1.4145	68.3333	70.0000	71.6667
July	1.4033	1.4897	1.1326	71.6667	75.0000	75.0000
August	2.1018	2.0852	1.5890	68.3333	66.6667	71.6667
September	1.4076	1.2234	1.0433	73.3333	76.6667	70.0000
October	1.3662	1.3497	1.0524	71.6667	75.0000	73.3333
November	0.9071	1.1403	0.7873	83.3333	76.6667	81.6667
December	0.6860	1.0109	0.7107	83.3333	80.0000	78.3333

Table 82: Monthly MAE and percentage values of number of people killed in Western Region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.4733	1.2070	0.6003	88.2353	82.3529	86.2745
February	0.2886	1.1834	0.4610	96.0784	88.2353	92.1569
March	0.5490	1.3685	0.5962	94.1176	88.2353	92.1569
April	0.5686	1.3916	0.7239	90.1961	84.3137	86.2745
May	0.5686	1.2277	0.5977	84.3137	74.5098	84.3137
June	1.0392	1.5606	1.1416	86.2745	76.4706	82.3529
July	0.2941	1.3426	0.6740	92.1569	76.4706	84.3137
August	0.7451	1.2228	0.7561	84.3137	80.3922	84.3137
September	0.3529	1.1836	0.5488	88.2353	78.4314	84.3137
October	0.8824	1.5273	0.9324	84.3137	80.3922	84.3137
November	0.1961	1.2030	0.4791	96.0784	80.3922	90.1961
December	0.4700	1.2428	0.5550	94.1176	88.2353	92.1569

Table 83: Monthly MAE and percentage values of number of people wounded in Western Region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.1443	1.3460	0.3487	98.0392	84.3137	94.1176
February	0.1435	1.3405	0.2897	98.0392	84.3137	94.1176
March	0.5543	1.3123	0.5779	90.1961	76.4706	90.1961
April	0.7413	1.7642	0.8494	84.3137	68.6275	84.3137
May	0.4765	1.6496	0.6163	92.1569	68.6275	86.2745
June	0.6504	1.6048	0.6905	84.3137	62.7451	84.3137
July	0.6730	1.5233	0.7831	88.2353	62.7451	82.3529
August	1.0840	1.5635	1.0449	82.3529	60.7843	78.4314
September	0.8052	1.3610	0.8808	90.1961	66.6667	82.3529
October	0.3945	1.2843	0.5422	90.1961	68.6275	84.3137
November	0.4907	1.6138	0.6566	90.1961	68.6275	84.3137
December	0.2861	1.4272	0.4634	92.1569	80.3922	86.2745

Table 84: Monthly MAE and percentage values of number of people hijacked in Western Region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.4314	0.4236	0.4325	92.1569	92.1569	92.1569
February	0.2941	0.5388	0.2993	98.0392	90.1961	98.0392
March	0.3137	0.4820	0.3208	94.1176	92.1569	94.1176
April	0.0000	0.1682	0.0053	100.000	94.1176	100.000
May	0.4118	0.4118	0.4165	94.1176	94.1176	94.1176
June	0.4510	0.3945	0.4553	90.1961	90.1961	90.1961
July	0.3725	0.5255	0.3771	92.1569	86.2745	92.1569
August	0.1961	0.4255	0.2008	94.1176	90.1961	94.1176
September	0.2941	0.3246	0.2985	90.1961	90.1961	90.1961
October	0.5686	0.7370	0.5733	94.1176	88.2353	94.1176
November	0.3529	1.4796	0.3562	96.0784	92.1569	96.0784
December	0.0980	0.2816	0.1035	98.0392	94.1176	98.0392

Table 85: Monthly MAE and percentage values of total number of adverse events in Western Region

Month	MAE			Percentage		
	ANN	FIS	ANFIS	ANN	FIS	ANFIS
January	0.5803	0.9108	0.6280	84.3137	70.5882	82.3529
February	0.2729	0.8392	0.3726	94.1176	72.5490	86.2745
March	0.4929	1.0163	0.5100	88.2353	78.4314	86.2745
April	0.5869	0.9430	0.4994	86.2745	70.5882	86.2745
May	0.6590	0.9782	0.6142	76.4706	60.7843	76.4706
June	1.2320	1.2373	0.9692	74.5098	74.5098	76.4706
July	1.0154	1.2554	0.8800	80.3922	66.6667	72.5490
August	0.7996	0.9284	0.6811	82.3529	74.5098	80.3922
September	0.8066	0.9124	0.6255	82.3529	82.3529	80.3922
October	0.6570	0.7338	0.4794	90.1961	94.1176	90.1961
November	0.3626	0.7683	0.4549	94.1176	90.1961	90.1961
December	0.4424	0.8836	0.4832	94.1176	90.1961	90.1961

APPENDIX F: SENSITIVITY ANALYSIS RESULTS FOR ALL RANKED INPUT VALUES

Table 86: The sensitivity rank of all input values for number of people wounded in central region

Central Region – Number of people wounded		
Rank	**Input name**	**Sensitivity value**
1	Urban female population density	0.073558
2	Number of water and sanitation project at year (t-2)	0.037574
3	Number of gender project at year (t-2)	0.036041
4	Number of commerce and industry project at year (t-1)	0.031016
5	Number of capacity building project at year (t-2)	0.022789
6	Number of security project at year (t-2)	0.020106
7	Health project budget at year (t-2)	0.017433
8	Health project budget at year (t)	0.016309
9	Number of capacity building project at year (t-1)	0.016307
10	Water and sanitation project budget at year (t-2)	0.015653
11	Urban male population density	0.015432
12	Number of commerce and industry project at year (t)	0.015392
13	Gender project budget at year (t-2)	0.015132
14	Number of energy project at year (t-2)	0.013781
15	Number of education project at year (t)	0.012612
16	Number of governance project at year (t-1)	0.012529
17	Number of health project at year (t-2)	0.009454
18	Security project budget at year (t-2)	0.008926
19	Number of health project at year (t)	0.008766
20	Number of capacity building project at year (t)	0.008596
21	Number of Community development project at year (t-1)	0.008423
22	Water and sanitation project budget at year (t)	0.007994
23	Number of emergency assistance project at year (t)	0.006677
24	Security project budget at year (t)	0.006667
25	Number of health project at year (t-1)	0.005844
26	Number of water and sanitation project at year (t)	0.005479
27	Emergency assistance project budget at year (t)	0.005271
28	Number of transport project at year (t-1)	0.005158
29	Environment project budget at year (t-2)	0.005134
30	Governance project budget at year (t-1)	0.004916
31	Number of agriculture project at year (t)	0.00486
32	Community development project budget at year (t)	0.004759
33	Number of transport project at year (t)	0.004755
34	Number of Community development project at year (t-2)	0.004728
35	Rural female population density	0.004507
36	Number of governance project at year (t-2)	0.004387
37	Number of Community development project at year (t)	0.004202
38	Number of commerce and industry project at year (t-2)	0.004079
39	Number of education project at year (t-2)	0.003998

Central Region – Number of people wounded		
Rank	**Input name**	**Sensitivity value**
40	Agriculture project budget at year (t-2)	0.003955
41	Number of governance project at year (t)	0.003818
42	Education project budget at year (t-1)	0.003595
43	Number of agriculture project at year (t-2)	0.003532
44	Capacity building project budget at year (t-1)	0.003448
45	Number of transport project at year (t-2)	0.003419
46	Transport project budget at year (t-2)	0.003356
47	Transport project budget at year (t-1)	0.003114
48	Number of energy project at year (t)	0.003032
49	Governance project budget at year (t)	0.003014
50	Energy project budget at year (t)	0.003007
51	Security project budget at year (t-1)	0.002942
52	Commerce and industry project budget at year (t)	0.002927
53	Water and sanitation project budget at year (t-1)	0.002792
54	Commerce and industry project budget at year (t-2)	0.002786
55	Transport project budget at year (t)	0.00273
56	Emergency assistance project budget at year (t-2)	0.002621
57	Community development project budget at year (t-1)	0.00258
58	Agriculture project budget at year (t-1)	0.002574
59	Number of environment project at year (t-1)	0.002444
60	Agriculture project budget at year (t)	0.00228
61	Energy project budget at year (t-2)	0.002257
62	Community development project budget at year (t-2)	0.002251
63	Environment project budget at year (t)	0.002167
64	Number of security project at year (t)	0.002159
65	Education project budget at year (t-2)	0.00205
66	Number of environment project at year (t-2)	0.002002
67	Capacity building project budget at year (t)	0.002
68	Gender project budget at year (t-1)	0.001941
69	Number of gender project at year (t)	0.001875
70	Environment project budget at year (t-1)	0.00184
71	Education project budget at year (t)	0.001749
72	Rural male population density	0.001719
73	Number of environment project at year (t)	0.001555
74	Number of education project at year (t-1)	0.001514
75	Health project budget at year (t-1)	0.001462
76	Governance project budget at year (t-2)	0.001385
77	Commerce and industry project budget at year (t-1)	0.001346
78	Number of agriculture project at year (t-1)	0.001298
79	Number of security project at year (t-1)	0.001208

Central Region – Number of people wounded		
Rank	**Input name**	**Sensitivity value**
80	Capacity building project budget at year (t-2)	0.001051
81	Energy project budget at year (t-1)	0.000761
82	Number of people wounded at month (t-1)	0.000741
83	Number of emergency assistance project at year (t-1)	0.00073
84	Number of gender project at year (t-1)	0.000715
85	Gender project budget at year (t)	0.000561
86	Number of energy project at year (t-1)	0.000337
87	Emergency assistance project budget at year (t-1)	0.000328
88	Number of emergency assistance project at year (t-2)	0.000307
89	Number of water and sanitation project at year (t-1)	0.000286

Table 87: The sensitivity rank of all input values for number of people hijacked in central region

Central Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
1	Urban female population density	0.036674
2	Number of education project at year (t-1)	0.031188
3	Agriculture project budget at year (t-2)	0.02739
4	Water and sanitation project budget at year (t)	0.025585
5	Number of water and sanitation project at year (t-2)	0.024482
6	Number of education project at year (t)	0.024033
7	Number of education project at year (t-2)	0.023539
8	Number of health project at year (t-1)	0.022816
9	Community development project budget at year (t-2)	0.019195
10	Agriculture project budget at year (t)	0.016569
11	Capacity building project budget at year (t-1)	0.016389
12	Number of commerce and industry project at year (t)	0.015767
13	Gender project budget at year (t)	0.014431
14	Number of emergency assistance project at year (t-1)	0.014049
15	Environment project budget at year (t)	0.014048
16	Number of Community development project at year (t-1)	0.013818
17	Health project budget at year (t-1)	0.013528
18	Water and sanitation project budget at year (t-2)	0.013437
19	Environment project budget at year (t-2)	0.012977
20	Commerce and industry project budget at year (t-1)	0.01284
21	Energy project budget at year (t-1)	0.011205
22	Urban male population density	0.010103
23	Number of emergency assistance project at year (t-2)	0.00974

Central Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
24	Transport project budget at year (t-1)	0.009426
25	Emergency assistance project budget at year (t-1)	0.00911
26	Number of agriculture project at year (t-2)	0.008982
27	Rural male population density	0.008214
28	Security project budget at year (t-2)	0.007649
29	Number of agriculture project at year (t-1)	0.007554
30	Education project budget at year (t-2)	0.006737
31	Capacity building project budget at year (t-2)	0.006463
32	Capacity building project budget at year (t)	0.006388
33	Number of governance project at year (t)	0.006378
34	Number of governance project at year (t-2)	0.006375
35	Number of capacity building project at year (t)	0.005948
36	Number of health project at year (t-2)	0.005646
37	Number of transport project at year (t)	0.005605
38	Transport project budget at year (t-2)	0.005525
39	Gender project budget at year (t-2)	0.005452
40	Number of health project at year (t)	0.005266
41	Transport project budget at year (t)	0.005214
42	Water and sanitation project budget at year (t-1)	0.00514
43	Number of security project at year (t)	0.005069
44	Health project budget at year (t)	0.004981
45	Number of environment project at year (t-1)	0.004827
46	Number of capacity building project at year (t-1)	0.004807
47	Number of commerce and industry project at year (t-2)	0.004765
48	Number of security project at year (t-2)	0.004757
49	Number of agriculture project at year (t)	0.004641
50	Emergency assistance project budget at year (t)	0.004608
51	Number of security project at year (t-1)	0.004595
52	Environment project budget at year (t-1)	0.004486
53	Number of governance project at year (t-1)	0.004479
54	Number of energy project at year (t-2)	0.004448
55	Rural female population density	0.004154
56	Number of energy project at year (t-1)	0.003734
57	Governance project budget at year (t)	0.003531
58	Education project budget at year (t-1)	0.003464
59	Number of water and sanitation project at year (t-1)	0.003391
60	Security project budget at year (t)	0.003388
61	Community development project budget at year (t-1)	0.003365
62	Commerce and industry project budget at year (t-2)	0.00334
63	Number of environment project at year (t-2)	0.003011

Central Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
64	Number of gender project at year (t)	0.003008
65	Education project budget at year (t)	0.002969
66	Governance project budget at year (t-1)	0.002951
67	Agriculture project budget at year (t-1)	0.002743
68	Number of gender project at year (t-2)	0.002451
69	Number of transport project at year (t-1)	0.002399
70	Energy project budget at year (t)	0.002344
71	Number of water and sanitation project at year (t)	0.002226
72	Number of emergency assistance project at year (t)	0.002219
73	Commerce and industry project budget at year (t)	0.002095
74	Energy project budget at year (t-2)	0.001995
75	Number of people hijacked at month (t-1)	0.001901
76	Governance project budget at year (t-2)	0.001863
77	Emergency assistance project budget at year (t-2)	0.001805
78	Number of environment project at year (t)	0.001571
79	Number of commerce and industry project at year (t-1)	0.001403
80	Number of capacity building project at year (t-2)	0.001043
81	Health project budget at year (t-2)	0.001026
82	Number of energy project at year (t)	0.000941
83	Number of Community development project at year (t-2)	0.000841
84	Number of transport project at year (t-2)	0.000806
85	Security project budget at year (t-1)	0.000749
86	Community development project budget at year (t)	0.000531
87	Gender project budget at year (t-1)	0.000513
88	Number of gender project at year (t-1)	0.000297
89	Number of Community development project at year (t)	2.91E-05

Table 88: The sensitivity rank of all input values for total number of adverse events in central region

Central Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
1	Total number of adverse events at month (t-1)	0.658433
2	Number of commerce and industry project at year (t-1)	0.063121
3	Urban male population density	0.053539
4	Urban female population density	0.047342
5	Gender project budget at year (t-2)	0.021578
6	Number of education project at year (t-2)	0.018678

Central Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
7	Agriculture project budget at year (t)	0.018622
8	Health project budget at year (t)	0.018514
9	Education project budget at year (t-1)	0.018136
10	Transport project budget at year (t-2)	0.015624
11	Number of energy project at year (t-2)	0.014989
12	Environment project budget at year (t-1)	0.014288
13	Number of transport project at year (t)	0.01333
14	Emergency assistance project budget at year (t-2)	0.012859
15	Commerce and industry project budget at year (t-2)	0.012649
16	Transport project budget at year (t-1)	0.012387
17	Number of water and sanitation project at year (t-2)	0.01216
18	Number of capacity building project at year (t-2)	0.011124
19	Number of Community development project at year (t-1)	0.011037
20	Capacity building project budget at year (t)	0.011018
21	Community development project budget at year (t-1)	0.010783
22	Environment project budget at year (t)	0.010717
23	Community development project budget at year (t-2)	0.010443
24	Number of Community development project at year (t-2)	0.010287
25	Governance project budget at year (t-2)	0.009727
26	Emergency assistance project budget at year (t-1)	0.009456
27	Number of gender project at year (t-2)	0.009117
28	Governance project budget at year (t)	0.008866
29	Number of transport project at year (t-2)	0.008655
30	Number of capacity building project at year (t)	0.008331
31	Gender project budget at year (t-1)	0.008178
32	Number of security project at year (t-1)	0.00811
33	Gender project budget at year (t)	0.008093
34	Number of health project at year (t-2)	0.007854
35	Number of governance project at year (t)	0.007837
36	Number of water and sanitation project at year (t-1)	0.007502
37	Energy project budget at year (t-2)	0.007435
38	Number of water and sanitation project at year (t)	0.007415
39	Agriculture project budget at year (t-1)	0.007379
40	Water and sanitation project budget at year (t-2)	0.007349
41	Capacity building project budget at year (t-1)	0.007202
42	Number of environment project at year (t)	0.006761
43	Number of governance project at year (t-1)	0.006712
44	Water and sanitation project budget at year (t-1)	0.006386
45	Number of agriculture project at year (t)	0.005904
46	Number of security project at year (t-2)	0.005821

Central Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
47	Number of energy project at year (t-1)	0.005741
48	Agriculture project budget at year (t-2)	0.005619
49	Health project budget at year (t-1)	0.005609
50	Number of commerce and industry project at year (t-2)	0.005451
51	Number of environment project at year (t-2)	0.005372
52	Rural male population density	0.005306
53	Number of commerce and industry project at year (t)	0.00511
54	Rural female population density	0.004797
55	Security project budget at year (t)	0.004703
56	Number of governance project at year (t-2)	0.004681
57	Number of emergency assistance project at year (t-1)	0.004596
58	Capacity building project budget at year (t-2)	0.004382
59	Number of agriculture project at year (t-2)	0.004382
60	Number of education project at year (t-1)	0.004265
61	Number of transport project at year (t-1)	0.004219
62	Number of agriculture project at year (t-1)	0.004049
63	Education project budget at year (t)	0.00356
64	Number of emergency assistance project at year (t)	0.003478
65	Commerce and industry project budget at year (t)	0.003324
66	Environment project budget at year (t-2)	0.003271
67	Governance project budget at year (t-1)	0.003107
68	Number of capacity building project at year (t-1)	0.003094
69	Community development project budget at year (t)	0.003034
70	Health project budget at year (t-2)	0.002977
71	Number of energy project at year (t)	0.002624
72	Number of education project at year (t)	0.002471
73	Number of environment project at year (t-1)	0.002412
74	Number of health project at year (t)	0.002411
75	Transport project budget at year (t)	0.002275
76	Number of security project at year (t)	0.002274
77	Number of gender project at year (t)	0.001874
78	Energy project budget at year (t-1)	0.001714
79	Water and sanitation project budget at year (t)	0.001259
80	Number of health project at year (t-1)	0.001168
81	Security project budget at year (t-1)	0.001142
82	Number of gender project at year (t-1)	0.001109
83	Number of Community development project at year (t)	0.001095
84	Energy project budget at year (t)	0.001028
85	Security project budget at year (t-2)	0.00101
86	Education project budget at year (t-2)	0.0008

Central Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
87	Number of emergency assistance project at year (t-2)	0.000777
88	Commerce and industry project budget at year (t-1)	0.000559
89	Emergency assistance project budget at year (t)	0.000369

Table 89: The sensitivity rank of all input values for number of people hijacked in eastern region

Eastern Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
1	Number of transport project at year (t-2)	0.105818
2	Environment project budget at year (t-1)	0.077204
3	Number of transport project at year (t-1)	0.071764
4	Number of capacity building project at year (t)	0.061765
5	Number of health project at year (t-2)	0.055047
6	Number of emergency assistance project at year (t-2)	0.05162
7	Rural male population density	0.04592
8	Number of gender project at year (t)	0.043762
9	Number of capacity building project at year (t-2)	0.037245
10	Urban female population density	0.036649
11	Agriculture project budget at year (t-1)	0.033327
12	Security project budget at year (t-1)	0.032966
13	Number of governance project at year (t)	0.032853
14	Number of commerce and industry project at year (t)	0.032262
15	Number of health project at year (t)	0.031789
16	Transport project budget at year (t-1)	0.02998
17	Number of Community development project at year (t)	0.029808
18	Number of water and sanitation project at year (t)	0.028562
19	Number of security project at year (t-1)	0.026883
20	Capacity building project budget at year (t-1)	0.026594
21	Security project budget at year (t)	0.024873
22	Environment project budget at year (t-2)	0.023374
23	Transport project budget at year (t)	0.022964
24	Education project budget at year (t)	0.022068
25	Number of gender project at year (t-2)	0.021847
26	Number of Community development project at year (t-1)	0.021843
27	Community development project budget at year (t-1)	0.02178
28	Energy project budget at year (t-1)	0.021669
29	Number of emergency assistance project at year (t-1)	0.020716
30	Emergency assistance project budget at year (t)	0.020107

Eastern Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
31	Number of emergency assistance project at year (t)	0.01971
32	Number of education project at year (t)	0.018762
33	Gender project budget at year (t-2)	0.018693
34	Number of gender project at year (t-1)	0.018081
35	Number of capacity building project at year (t-1)	0.017735
36	Number of security project at year (t-2)	0.017562
37	Education project budget at year (t-1)	0.017506
38	Transport project budget at year (t-2)	0.016781
39	Water and sanitation project budget at year (t)	0.016732
40	Community development project budget at year (t-2)	0.016575
41	Capacity building project budget at year (t)	0.016321
42	Number of agriculture project at year (t-2)	0.01597
43	Health project budget at year (t-2)	0.015263
44	Energy project budget at year (t-2)	0.01384
45	Number of commerce and industry project at year (t-2)	0.013815
46	Water and sanitation project budget at year (t-1)	0.013287
47	Health project budget at year (t)	0.013189
48	Number of security project at year (t)	0.013018
49	Number of environment project at year (t-1)	0.012736
50	Number of health project at year (t-1)	0.012658
51	Community development project budget at year (t)	0.012566
52	Education project budget at year (t-2)	0.012402
53	Number of education project at year (t-1)	0.012243
54	Environment project budget at year (t)	0.012017
55	Capacity building project budget at year (t-2)	0.011731
56	Number of agriculture project at year (t-1)	0.011665
57	Number of energy project at year (t-2)	0.010981
58	Commerce and industry project budget at year (t-1)	0.010848
59	Agriculture project budget at year (t)	0.009774
60	Gender project budget at year (t-1)	0.00968
61	Gender project budget at year (t)	0.008739
62	Number of agriculture project at year (t)	0.008244
63	Urban male population density	0.008199
64	Commerce and industry project budget at year (t-2)	0.008198
65	Governance project budget at year (t-2)	0.007454
66	Number of education project at year (t-2)	0.007398
67	Health project budget at year (t-1)	0.007199
68	Governance project budget at year (t-1)	0.007162
69	Security project budget at year (t-2)	0.006881
70	Water and sanitation project budget at year (t-2)	0.006617

Eastern Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
71	Number of transport project at year (t)	0.006575
72	Emergency assistance project budget at year (t-2)	0.006311
73	Rural female population density	0.006135
74	Governance project budget at year (t)	0.005881
75	Number of governance project at year (t-2)	0.005857
76	Number of water and sanitation project at year (t-1)	0.005725
77	Commerce and industry project budget at year (t)	0.00486
78	Energy project budget at year (t)	0.00483
79	Number of energy project at year (t)	0.004714
80	Emergency assistance project budget at year (t-1)	0.004075
81	Number of people killed at month (t-1)	0.002924
82	Number of energy project at year (t-1)	0.002781
83	Number of environment project at year (t-2)	0.002772
84	Number of environment project at year (t)	0.002338
85	Number of commerce and industry project at year (t-1)	0.00201
86	Number of governance project at year (t-1)	0.001839
87	Number of Community development project at year (t-2)	0.001719
88	Number of water and sanitation project at year (t-2)	0.001659
89	Agriculture project budget at year (t-2)	0.001133

Table 90: The sensitivity rank of all input values for number of people wounded in eastern region

Eastern Region – Number of people wounded		
Rank	**Input name**	**Sensitivity value**
1	Security project budget at year (t-2)	0.089043
2	Water and sanitation project budget at year (t-1)	0.081146
3	Number of transport project at year (t)	0.068961
4	Number of environment project at year (t-1)	0.062452
5	Agriculture project budget at year (t-1)	0.050546
6	Security project budget at year (t-1)	0.047557
7	Number of energy project at year (t)	0.046182
8	Health project budget at year (t-2)	0.043664
9	Number of education project at year (t-1)	0.041967
10	Health project budget at year (t)	0.041353
11	Health project budget at year (t-1)	0.041244
12	Number of capacity building project at year (t-1)	0.035541

Eastern Region – Number of people wounded		
Rank	**Input name**	**Sensitivity value**
13	Number of capacity building project at year (t)	0.035087
14	Environment project budget at year (t-1)	0.034599
15	Number of environment project at year (t-2)	0.033876
16	Number of transport project at year (t-1)	0.032957
17	Water and sanitation project budget at year (t-2)	0.032054
18	Commerce and industry project budget at year (t-2)	0.031654
19	Number of security project at year (t-2)	0.031571
20	Number of commerce and industry project at year (t-2)	0.03113
21	Number of energy project at year (t-2)	0.030978
22	Energy project budget at year (t-2)	0.030908
23	Capacity building project budget at year (t)	0.030364
24	Number of energy project at year (t-1)	0.029298
25	Gender project budget at year (t-2)	0.028923
26	Number of environment project at year (t)	0.028116
27	Number of agriculture project at year (t)	0.027486
28	Number of capacity building project at year (t-2)	0.027389
29	Number of Community development project at year (t-2)	0.026208
30	Number of commerce and industry project at year (t-1)	0.025194
31	Capacity building project budget at year (t-2)	0.024744
32	Emergency assistance project budget at year (t-2)	0.024205
33	Number of gender project at year (t-1)	0.024181
34	Number of people wounded at month (t-1)	0.023721
35	Commerce and industry project budget at year (t-1)	0.023534
36	Energy project budget at year (t)	0.022037
37	Transport project budget at year (t)	0.021641
38	Urban male population density	0.021574
39	Number of governance project at year (t-2)	0.020951
40	Number of agriculture project at year (t-2)	0.020465
41	Governance project budget at year (t-2)	0.020209
42	Number of commerce and industry project at year (t)	0.018012
43	Number of water and sanitation project at year (t-1)	0.017666
44	Number of emergency assistance project at year (t)	0.017646
45	Transport project budget at year (t-2)	0.017507
46	Number of Community development project at year (t)	0.017381
47	Number of water and sanitation project at year (t)	0.017138
48	Number of education project at year (t-2)	0.016686
49	Emergency assistance project budget at year (t-1)	0.016645
50	Gender project budget at year (t)	0.016549
51	Commerce and industry project budget at year (t)	0.015996
52	Emergency assistance project budget at year (t)	0.015495

Eastern Region – Number of people wounded		
Rank	**Input name**	**Sensitivity value**
53	Community development project budget at year (t-1)	0.015231
54	Education project budget at year (t-2)	0.013642
55	Transport project budget at year (t-1)	0.013402
56	Number of gender project at year (t)	0.013315
57	Agriculture project budget at year (t-2)	0.013199
58	Number of education project at year (t)	0.013182
59	Number of governance project at year (t-1)	0.012689
60	Environment project budget at year (t-2)	0.012281
61	Number of water and sanitation project at year (t-2)	0.012011
62	Number of transport project at year (t-2)	0.011268
63	Gender project budget at year (t-1)	0.011039
64	Community development project budget at year (t)	0.010842
65	Number of gender project at year (t-2)	0.010789
66	Environment project budget at year (t)	0.010217
67	Community development project budget at year (t-2)	0.009776
68	Number of Community development project at year (t-1)	0.009713
69	Number of security project at year (t)	0.009419
70	Capacity building project budget at year (t-1)	0.009184
71	Rural male population density	0.008908
72	Number of security project at year (t-1)	0.007878
73	Number of emergency assistance project at year (t-1)	0.007417
74	Number of governance project at year (t)	0.007383
75	Energy project budget at year (t-1)	0.006996
76	Number of health project at year (t-2)	0.006907
77	Urban female population density	0.006571
78	Number of health project at year (t-1)	0.005771
79	Education project budget at year (t)	0.005371
80	Security project budget at year (t)	0.005342
81	Governance project budget at year (t-1)	0.00471
82	Number of emergency assistance project at year (t-2)	0.004439
83	Number of agriculture project at year (t-1)	0.003694
84	Agriculture project budget at year (t)	0.00358
85	Water and sanitation project budget at year (t)	0.003416
86	Rural female population density	0.003322
87	Education project budget at year (t-1)	0.002997
88	Governance project budget at year (t)	0.002231
89	Number of health project at year (t)	0.000397

Table 91: The sensitivity rank of all input values for number of people hijacked in eastern region

Eastern Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
1	Security project budget at year (t-2)	0.003908
2	Education project budget at year (t)	0.003707
3	Number of education project at year (t-2)	0.003523
4	Number of gender project at year (t)	0.003253
5	Gender project budget at year (t)	0.00321
6	Governance project budget at year (t-2)	0.003121
7	Education project budget at year (t-2)	0.003109
8	Number of education project at year (t)	0.00307
9	Number of security project at year (t)	0.003068
10	Number of people hijacked at month (t-1)	0.003051
11	Commerce and industry project budget at year (t-1)	0.002852
12	Capacity building project budget at year (t-2)	0.00279
13	Community development project budget at year (t-2)	0.002768
14	Number of capacity building project at year (t-2)	0.002754
15	Number of gender project at year (t-1)	0.002754
16	Number of environment project at year (t-2)	0.002702
17	Number of capacity building project at year (t-1)	0.002693
18	Capacity building project budget at year (t)	0.002661
19	Number of water and sanitation project at year (t-1)	0.00266
20	Transport project budget at year (t-1)	0.002622
21	Agriculture project budget at year (t-2)	0.002526
22	Number of commerce and industry project at year (t-2)	0.002518
23	Transport project budget at year (t)	0.002509
24	Rural male population density	0.002503
25	Emergency assistance project budget at year (t)	0.002449
26	Number of environment project at year (t)	0.002402
27	Number of energy project at year (t)	0.002393
28	Environment project budget at year (t-2)	0.002332
29	Community development project budget at year (t-1)	0.002323
30	Urban male population density	0.002283
31	Number of agriculture project at year (t-2)	0.002235
32	Energy project budget at year (t)	0.002224
33	Number of health project at year (t-2)	0.002118
34	Agriculture project budget at year (t-1)	0.002113
35	Number of emergency assistance project at year (t-1)	0.002033
36	Number of health project at year (t-1)	0.002022
37	Number of governance project at year (t-2)	0.002012
38	Energy project budget at year (t-2)	0.001941
39	Number of security project at year (t-1)	0.001922

Eastern Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
40	Number of energy project at year (t-2)	0.00188
41	Water and sanitation project budget at year (t)	0.001829
42	Security project budget at year (t)	0.001825
43	Gender project budget at year (t-2)	0.001788
44	Rural female population density	0.001762
45	Number of health project at year (t)	0.001761
46	Number of environment project at year (t-1)	0.001743
47	Number of commerce and industry project at year (t)	0.001735
48	Emergency assistance project budget at year (t-1)	0.001706
49	Number of agriculture project at year (t-1)	0.001697
50	Number of commerce and industry project at year (t-1)	0.001684
51	Number of education project at year (t-1)	0.001682
52	Number of emergency assistance project at year (t)	0.001656
53	Commerce and industry project budget at year (t)	0.00157
54	Water and sanitation project budget at year (t-1)	0.00151
55	Number of agriculture project at year (t)	0.001448
56	Number of governance project at year (t)	0.001407
57	Health project budget at year (t-2)	0.001398
58	Health project budget at year (t)	0.001394
59	Number of gender project at year (t-2)	0.001327
60	Number of security project at year (t-2)	0.001282
61	Number of water and sanitation project at year (t-2)	0.001264
62	Number of energy project at year (t-1)	0.001242
63	Energy project budget at year (t-1)	0.00123
64	Commerce and industry project budget at year (t-2)	0.001209
65	Health project budget at year (t-1)	0.00119
66	Water and sanitation project budget at year (t-2)	0.001147
67	Education project budget at year (t-1)	0.001043
68	Number of capacity building project at year (t)	0.000961
69	Capacity building project budget at year (t-1)	0.00095
70	Transport project budget at year (t-2)	0.000872
71	Number of transport project at year (t-2)	0.000865
72	Emergency assistance project budget at year (t-2)	0.00086
73	Urban female population density	0.000837
74	Number of water and sanitation project at year (t)	0.000815
75	Governance project budget at year (t)	0.000811
76	Security project budget at year (t-1)	0.00079
77	Community development project budget at year (t)	0.000788
78	Number of Community development project at year (t)	0.000735
79	Number of transport project at year (t)	0.000644

Eastern Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
80	Number of emergency assistance project at year (t-2)	0.000612
81	Number of Community development project at year (t-1)	0.000516
82	Number of transport project at year (t-1)	0.000424
83	Number of Community development project at year (t-2)	0.000391
84	Agriculture project budget at year (t)	0.000385
85	Number of governance project at year (t-1)	0.000285
86	Environment project budget at year (t)	0.000264
87	Environment project budget at year (t-1)	0.00022
88	Governance project budget at year (t-1)	0.000193
89	Gender project budget at year (t-1)	0.000159

Table 92: The sensitivity rank of all input values for total number of adverse events in eastern region

Eastern Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
1	Number of transport project at year (t-2)	0.852394
2	Number of emergency assistance project at year (t-1)	0.68422
3	Number of Community development project at year (t)	0.57364
4	Number of Community development project at year (t-2)	0.350883
5	Number of environment project at year (t-1)	0.320033
6	Capacity building project budget at year (t)	0.260339
7	Emergency assistance project budget at year (t-2)	0.244893
8	Urban male population density	0.23173
9	Number of gender project at year (t-1)	0.211639
10	Number of Community development project at year (t-1)	0.192749
11	Total number of adverse events at month (t-1)	0.178621
12	Number of environment project at year (t-2)	0.170775
13	Rural male population density	0.168686
14	Number of commerce and industry project at year (t)	0.161589
15	Community development project budget at year (t-2)	0.160942
16	Number of gender project at year (t)	0.15348
17	Education project budget at year (t)	0.152942
18	Number of commerce and industry project at year (t-2)	0.151073
19	Water and sanitation project budget at year (t-1)	0.149142
20	Gender project budget at year (t-1)	0.148067

Eastern Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
21	Number of governance project at year (t)	0.146128
22	Governance project budget at year (t-1)	0.144091
23	Emergency assistance project budget at year (t)	0.141364
24	Education project budget at year (t-1)	0.138448
25	Number of water and sanitation project at year (t)	0.129897
26	Environment project budget at year (t)	0.12855
27	Number of energy project at year (t)	0.127341
28	Capacity building project budget at year (t-1)	0.125064
29	Number of governance project at year (t-2)	0.1204
30	Number of education project at year (t-2)	0.119403
31	Emergency assistance project budget at year (t-1)	0.118518
32	Agriculture project budget at year (t-1)	0.11011
33	Water and sanitation project budget at year (t-2)	0.104188
34	Gender project budget at year (t-2)	0.103606
35	Number of agriculture project at year (t)	0.102151
36	Energy project budget at year (t-2)	0.101982
37	Environment project budget at year (t-1)	0.096211
38	Education project budget at year (t-2)	0.094488
39	Commerce and industry project budget at year (t-1)	0.091732
40	Number of agriculture project at year (t-2)	0.087751
41	Number of education project at year (t)	0.086924
42	Health project budget at year (t)	0.085621
43	Commerce and industry project budget at year (t-2)	0.085218
44	Number of water and sanitation project at year (t-2)	0.082925
45	Agriculture project budget at year (t-2)	0.079834
46	Transport project budget at year (t-2)	0.077074
47	Gender project budget at year (t)	0.074587
48	Number of education project at year (t-1)	0.074482
49	Number of capacity building project at year (t)	0.070573
50	Number of security project at year (t-1)	0.06832
51	Energy project budget at year (t)	0.064271
52	Security project budget at year (t)	0.063558
53	Number of emergency assistance project at year (t-2)	0.062867
54	Capacity building project budget at year (t-2)	0.061843
55	Number of health project at year (t)	0.061315
56	Number of security project at year (t)	0.059466
57	Number of health project at year (t-2)	0.057347
58	Number of environment project at year (t)	0.054568
59	Community development project budget at year (t)	0.053687
60	Rural female population density	0.052913

Eastern Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
61	Health project budget at year (t-2)	0.052731
62	Number of security project at year (t-2)	0.051967
63	Commerce and industry project budget at year (t)	0.051856
64	Number of emergency assistance project at year (t)	0.051428
65	Number of transport project at year (t)	0.05109
66	Urban female population density	0.050395
67	Number of gender project at year (t-2)	0.04973
68	Health project budget at year (t-1)	0.049725
69	Energy project budget at year (t-1)	0.048971
70	Community development project budget at year (t-1)	0.043213
71	Number of water and sanitation project at year (t-1)	0.042404
72	Governance project budget at year (t)	0.036701
73	Number of capacity building project at year (t-2)	0.032989
74	Number of agriculture project at year (t-1)	0.032644
75	Number of transport project at year (t-1)	0.031698
76	Transport project budget at year (t)	0.028093
77	Number of health project at year (t-1)	0.027662
78	Security project budget at year (t-2)	0.025764
79	Security project budget at year (t-1)	0.025403
80	Environment project budget at year (t-2)	0.024859
81	Transport project budget at year (t-1)	0.024148
82	Number of energy project at year (t-2)	0.024087
83	Number of energy project at year (t-1)	0.017229
84	Water and sanitation project budget at year (t)	0.010496
85	Governance project budget at year (t-2)	0.009145
86	Agriculture project budget at year (t)	0.003782
87	Number of capacity building project at year (t-1)	0.003631
88	Number of governance project at year (t-1)	0.003309
89	Number of commerce and industry project at year (t-1)	0.001449

Table 93: The sensitivity rank of all input values for number of people killed in north eastern region

North Eastern Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
1	Security project budget at year (t)	0.043348

North Eastern Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
2	Agriculture project budget at year (t-2)	0.037114
3	Community development project budget at year (t-2)	0.035992
4	Number of commerce and industry project at year (t-2)	0.033032
5	Number of environment project at year (t)	0.031515
6	Gender project budget at year (t-2)	0.027962
7	Number of Community development project at year (t-2)	0.027339
8	Number of gender project at year (t-1)	0.026431
9	Number of Community development project at year (t)	0.025577
10	Number of governance project at year (t)	0.023564
11	Commerce and industry project budget at year (t)	0.023564
12	Water and sanitation project budget at year (t-2)	0.023501
13	Number of health project at year (t-2)	0.021834
14	Number of security project at year (t-2)	0.021001
15	Emergency assistance project budget at year (t-2)	0.018841
16	Rural female population density	0.018295
17	Number of health project at year (t-1)	0.01798
18	Emergency assistance project budget at year (t)	0.017252
19	Number of capacity building project at year (t-1)	0.017132
20	Capacity building project budget at year (t)	0.017023
21	Health project budget at year (t)	0.016571
22	Number of transport project at year (t-1)	0.016439
23	Number of education project at year (t)	0.015262
24	Number of agriculture project at year (t)	0.014274
25	Number of emergency assistance project at year (t-2)	0.013927
26	Transport project budget at year (t)	0.01391
27	Health project budget at year (t-1)	0.013666
28	Number of commerce and industry project at year (t-1)	0.013369
29	Energy project budget at year (t-1)	0.013227
30	Commerce and industry project budget at year (t-1)	0.013098
31	Urban female population density	0.013046
32	Number of Community development project at year (t-1)	0.012399
33	Urban male population density	0.011594
34	Number of security project at year (t-1)	0.011483
35	Agriculture project budget at year (t)	0.011305
36	Number of energy project at year (t-1)	0.010984
37	Energy project budget at year (t)	0.01088
38	Number of agriculture project at year (t-1)	0.010586
39	Community development project budget at year (t)	0.010431
40	Number of governance project at year (t-1)	0.010285
41	Water and sanitation project budget at year (t)	0.010143

North Eastern Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
42	Number of gender project at year (t-2)	0.010087
43	Number of governance project at year (t-2)	0.009919
44	Gender project budget at year (t)	0.009842
45	Number of education project at year (t-1)	0.009605
46	Number of environment project at year (t-2)	0.009477
47	Water and sanitation project budget at year (t-1)	0.009029
48	Number of capacity building project at year (t)	0.008989
49	Education project budget at year (t-1)	0.008855
50	Education project budget at year (t-2)	0.008797
51	Number of education project at year (t-2)	0.008059
52	Number of transport project at year (t)	0.007878
53	Education project budget at year (t)	0.007836
54	Environment project budget at year (t)	0.007598
55	Number of water and sanitation project at year (t)	0.00696
56	Capacity building project budget at year (t-1)	0.006924
57	Gender project budget at year (t-1)	0.006766
58	Number of energy project at year (t-2)	0.0067
59	Governance project budget at year (t-2)	0.006532
60	Energy project budget at year (t-2)	0.00647
61	Number of water and sanitation project at year (t-1)	0.006386
62	Transport project budget at year (t-2)	0.006066
63	Agriculture project budget at year (t-1)	0.006038
64	Emergency assistance project budget at year (t-1)	0.005844
65	Environment project budget at year (t-1)	0.005563
66	Number of agriculture project at year (t-2)	0.005426
67	Number of energy project at year (t)	0.005083
68	Number of emergency assistance project at year (t)	0.004869
69	Number of environment project at year (t-1)	0.004656
70	Security project budget at year (t-1)	0.004331
71	Rural male population density	0.004298
72	Number of capacity building project at year (t-2)	0.004026
73	Environment project budget at year (t-2)	0.003735
74	Number of health project at year (t)	0.003621
75	Health project budget at year (t-2)	0.002872
76	Governance project budget at year (t-1)	0.002265
77	Number of commerce and industry project at year (t)	0.002161
78	Commerce and industry project budget at year (t-2)	0.001872
79	Number of water and sanitation project at year (t-2)	0.00186
80	Number of emergency assistance project at year (t-1)	0.001782
81	Number of transport project at year (t-2)	0.001686

North Eastern Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
82	Capacity building project budget at year (t-2)	0.001625
83	Number of security project at year (t)	0.001447
84	Security project budget at year (t-2)	0.001385
85	Community development project budget at year (t-1)	0.001338
86	Transport project budget at year (t-1)	0.001013
87	Number of gender project at year (t)	0.000632
88	Number of people killed at month (t-1)	0.000521
89	Governance project budget at year (t)	0.0003

Table 94: The sensitivity rank of all input values for number of people wounded in north eastern region

North Eastern Region – Number of people wounded		
Rank	**Input name**	**Sensitivity value**
1	Transport project budget at year (t)	0.278173
2	Transport project budget at year (t-1)	0.267052
3	Transport project budget at year (t-2)	0.25852
4	Number of transport project at year (t-2)	0.242853
5	Number of transport project at year (t-1)	0.23917
6	Water and sanitation project budget at year (t-2)	0.237693
7	Number of emergency assistance project at year (t-1)	0.236187
8	Emergency assistance project budget at year (t-2)	0.234841
9	Number of emergency assistance project at year (t)	0.234512
10	Number of gender project at year (t-2)	0.234244
11	Number of water and sanitation project at year (t-2)	0.232928
12	Gender project budget at year (t-1)	0.230594
13	Emergency assistance project budget at year (t)	0.230554
14	Water and sanitation project budget at year (t-1)	0.230446
15	Emergency assistance project budget at year (t-1)	0.229775
16	Energy project budget at year (t-2)	0.229681
17	Security project budget at year (t)	0.229468
18	Gender project budget at year (t)	0.228968
19	Water and sanitation project budget at year (t)	0.227625
20	Energy project budget at year (t)	0.227252
21	Number of water and sanitation project at year (t-1)	0.226053
22	Number of energy project at year (t-1)	0.225642

North Eastern Region – Number of people wounded		
Rank	**Input name**	**Sensitivity value**
23	Number of environment project at year (t-2)	0.224855
24	Number of people wounded at month (t-1)	0.224437
25	Number of transport project at year (t)	0.224334
26	Number of water and sanitation project at year (t)	0.223086
27	Number of environment project at year (t)	0.222973
28	Number of emergency assistance project at year (t-2)	0.222758
29	Number of energy project at year (t)	0.22208
30	Number of gender project at year (t-1)	0.221509
31	Number of energy project at year (t-2)	0.221252
32	Number of security project at year (t)	0.221128
33	Agriculture project budget at year (t)	0.220161
34	Environment project budget at year (t-2)	0.219781
35	Agriculture project budget at year (t-2)	0.219472
36	Environment project budget at year (t)	0.218327
37	Number of environment project at year (t-1)	0.217679
38	Energy project budget at year (t-1)	0.216102
39	Environment project budget at year (t-1)	0.215626
40	Security project budget at year (t-2)	0.215417
41	Number of capacity building project at year (t-1)	0.213957
42	Number of capacity building project at year (t-2)	0.213198
43	Number of security project at year (t-1)	0.212722
44	Security project budget at year (t-1)	0.212375
45	Gender project budget at year (t-2)	0.211948
46	Number of gender project at year (t)	0.211834
47	Agriculture project budget at year (t-1)	0.211283
48	Number of agriculture project at year (t)	0.203784
49	Number of agriculture project at year (t-1)	0.203663
50	Number of capacity building project at year (t)	0.203357
51	Number of Community development project at year (t-2)	0.201811
52	Number of agriculture project at year (t-2)	0.201184
53	Number of security project at year (t-2)	0.200592
54	Number of education project at year (t-2)	0.197772
55	Number of education project at year (t-1)	0.196861
56	Number of commerce and industry project at year (t-2)	0.196765
57	Number of health project at year (t-2)	0.196016
58	Community development project budget at year (t-2)	0.194513
59	Number of health project at year (t-1)	0.187132
60	Number of commerce and industry project at year (t-1)	0.184117
61	Health project budget at year (t-2)	0.182875
62	Number of education project at year (t)	0.18145

North Eastern Region – Number of people wounded		
Rank	**Input name**	**Sensitivity value**
63	Community development project budget at year (t-1)	0.180502
64	Number of Community development project at year (t-1)	0.179351
65	Number of health project at year (t)	0.17896
66	Number of governance project at year (t-2)	0.176779
67	Capacity building project budget at year (t-2)	0.173149
68	Education project budget at year (t)	0.170972
69	Health project budget at year (t-1)	0.170809
70	Urban male population density	0.170409
71	Number of governance project at year (t)	0.166528
72	Number of commerce and industry project at year (t)	0.163739
73	Number of Community development project at year (t)	0.161229
74	Health project budget at year (t)	0.161127
75	Urban female population density	0.160953
76	Number of governance project at year (t-1)	0.154778
77	Commerce and industry project budget at year (t-2)	0.142736
78	Governance project budget at year (t-2)	0.137987
79	Capacity building project budget at year (t-1)	0.134735
80	Community development project budget at year (t)	0.130154
81	Governance project budget at year (t)	0.125901
82	Governance project budget at year (t-1)	0.116733
83	Education project budget at year (t-1)	0.115065
84	Commerce and industry project budget at year (t)	0.111746
85	Capacity building project budget at year (t)	0.105215
86	Commerce and industry project budget at year (t-1)	0.101499
87	Rural female population density	0.092629
88	Rural male population density	0.092292
89	Education project budget at year (t-2)	0.080752

Table 95: The sensitivity rank of all input values for number of people hijacked in north eastern region

North Eastern Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
1	Transport project budget at year (t)	0.020359
2	Transport project budget at year (t-1)	0.014546
3	Community development project budget at year (t-1)	0.009074
4	Capacity building project budget at year (t-2)	0.008965
5	Number of Community development project at year (t-2)	0.008412

North Eastern Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
6	Transport project budget at year (t-2)	0.007879
7	Community development project budget at year (t-2)	0.007783
8	Number of governance project at year (t-2)	0.007635
9	Community development project budget at year (t)	0.007501
10	Capacity building project budget at year (t-1)	0.006609
11	Commerce and industry project budget at year (t-2)	0.006562
12	Number of transport project at year (t-2)	0.006333
13	Number of education project at year (t-1)	0.006167
14	Number of commerce and industry project at year (t-2)	0.006049
15	Number of transport project at year (t-1)	0.00551
16	Number of agriculture project at year (t-1)	0.005508
17	Number of education project at year (t-2)	0.005493
18	Number of education project at year (t)	0.00547
19	Number of transport project at year (t)	0.005388
20	Education project budget at year (t-2)	0.005381
21	Number of gender project at year (t-1)	0.005283
22	Number of agriculture project at year (t-2)	0.005258
23	Number of gender project at year (t-2)	0.005197
24	Capacity building project budget at year (t)	0.005052
25	Number of capacity building project at year (t-1)	0.005042
26	Number of capacity building project at year (t-2)	0.005035
27	Governance project budget at year (t-2)	0.005028
28	Number of governance project at year (t-1)	0.005003
29	Agriculture project budget at year (t-2)	0.00489
30	Number of environment project at year (t-1)	0.004848
31	Rural male population density	0.004704
32	Number of Community development project at year (t-1)	0.004662
33	Education project budget at year (t-1)	0.004549
34	Number of commerce and industry project at year (t-1)	0.004482
35	Number of gender project at year (t)	0.00448
36	Commerce and industry project budget at year (t-1)	0.004448
37	Number of capacity building project at year (t)	0.004382
38	Governance project budget at year (t-1)	0.004335
39	Commerce and industry project budget at year (t)	0.00428
40	Number of energy project at year (t)	0.00425
41	Number of Community development project at year (t)	0.003976
42	Rural female population density	0.003895
43	Number of commerce and industry project at year (t)	0.003893
44	Number of health project at year (t-2)	0.003799
45	Agriculture project budget at year (t-1)	0.003772

North Eastern Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
46	Security project budget at year (t-2)	0.003687
47	Environment project budget at year (t-2)	0.003621
48	Number of security project at year (t-1)	0.003614
49	Governance project budget at year (t)	0.003581
50	Health project budget at year (t-2)	0.003547
51	Education project budget at year (t)	0.003524
52	Emergency assistance project budget at year (t-2)	0.00348
53	Water and sanitation project budget at year (t)	0.003445
54	Number of energy project at year (t-1)	0.003422
55	Number of environment project at year (t-2)	0.003379
56	Emergency assistance project budget at year (t)	0.00337
57	Number of governance project at year (t)	0.003367
58	Number of energy project at year (t-2)	0.003297
59	Number of agriculture project at year (t)	0.003291
60	Water and sanitation project budget at year (t-1)	0.003245
61	Number of water and sanitation project at year (t-2)	0.003047
62	Energy project budget at year (t-2)	0.003004
63	Health project budget at year (t-1)	0.002981
64	Health project budget at year (t)	0.002959
65	Number of emergency assistance project at year (t-2)	0.002946
66	Emergency assistance project budget at year (t-1)	0.002927
67	Security project budget at year (t)	0.002872
68	Gender project budget at year (t-1)	0.002851
69	Number of security project at year (t)	0.002818
70	Number of emergency assistance project at year (t)	0.002798
71	Agriculture project budget at year (t)	0.002785
72	Gender project budget at year (t)	0.002754
73	Energy project budget at year (t)	0.002751
74	Gender project budget at year (t-2)	0.002723
75	Number of emergency assistance project at year (t-1)	0.002663
76	Number of water and sanitation project at year (t-1)	0.002628
77	Number of health project at year (t-1)	0.002564
78	Security project budget at year (t-1)	0.002536
79	Number of security project at year (t-2)	0.002451
80	Environment project budget at year (t)	0.002441
81	Environment project budget at year (t-1)	0.002432
82	Number of environment project at year (t)	0.002413
83	Number of people hijacked at month (t-1)	0.00238
84	Number of water and sanitation project at year (t)	0.002347
85	Energy project budget at year (t-1)	0.002312

North Eastern Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
86	Water and sanitation project budget at year (t-2)	0.002216
87	Number of health project at year (t)	0.002002
88	Urban female population density	0.001785
89	Urban male population density	0.001606

Table 96: The sensitivity rank of all input values for total number of adverse events in north eastern region

North Eastern Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
1	Total number of adverse events at month (t-1)	0.232663
2	Number of commerce and industry project at year (t-1)	0.014815
3	Health project budget at year (t)	0.00659
4	Number of agriculture project at year (t-1)	0.005825
5	Number of commerce and industry project at year (t-2)	0.005294
6	Community development project budget at year (t-2)	0.00491
7	Number of education project at year (t)	0.003932
8	Urban male population density	0.003834
9	Number of Community development project at year (t-2)	0.003102
10	Gender project budget at year (t)	0.002959
11	Number of health project at year (t)	0.002661
12	Water and sanitation project budget at year (t)	0.0026
13	Rural female population density	0.00225
14	Urban female population density	0.001884
15	Number of education project at year (t-1)	0.001785
16	Number of water and sanitation project at year (t)	0.001581
17	Environment project budget at year (t-2)	0.001572
18	Number of emergency assistance project at year (t)	0.00146
19	Number of gender project at year (t)	0.001402
20	Number of gender project at year (t-2)	0.001377
21	Number of Community development project at year (t-1)	0.001213
22	Number of capacity building project at year (t-2)	0.00115
23	Governance project budget at year (t)	0.001048
24	Transport project budget at year (t)	0.00104
25	Number of energy project at year (t-1)	0.001036
26	Number of commerce and industry project at year (t)	0.001014

North Eastern Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
27	Number of agriculture project at year (t)	0.000843
28	Number of transport project at year (t-1)	0.000836
29	Capacity building project budget at year (t)	0.000824
30	Education project budget at year (t-2)	0.000812
31	Community development project budget at year (t)	0.000791
32	Capacity building project budget at year (t-2)	0.000784
33	Energy project budget at year (t)	0.00077
34	Number of education project at year (t-2)	0.000769
35	Rural male population density	0.000719
36	Number of energy project at year (t)	0.000693
37	Number of environment project at year (t)	0.00068
38	Gender project budget at year (t-1)	0.000669
39	Security project budget at year (t-1)	0.000662
40	Number of transport project at year (t-2)	0.000658
41	Number of environment project at year (t-1)	0.000637
42	Number of health project at year (t-1)	0.000633
43	Health project budget at year (t-2)	0.000627
44	Number of capacity building project at year (t)	0.000578
45	Community development project budget at year (t-1)	0.000536
46	Agriculture project budget at year (t-1)	0.000531
47	Security project budget at year (t)	0.000504
48	Number of emergency assistance project at year (t-1)	0.000491
49	Emergency assistance project budget at year (t)	0.000485
50	Commerce and industry project budget at year (t-2)	0.000471
51	Agriculture project budget at year (t)	0.000469
52	Number of governance project at year (t-2)	0.000462
53	Number of water and sanitation project at year (t-1)	0.00044
54	Commerce and industry project budget at year (t-1)	0.000422
55	Education project budget at year (t)	0.000385
56	Water and sanitation project budget at year (t-1)	0.000375
57	Security project budget at year (t-2)	0.000368
58	Number of Community development project at year (t)	0.000367
59	Energy project budget at year (t-1)	0.000339
60	Capacity building project budget at year (t-1)	0.000333
61	Health project budget at year (t-1)	0.000319
62	Agriculture project budget at year (t-2)	0.000315
63	Number of security project at year (t)	0.000308
64	Number of environment project at year (t-2)	0.000293
65	Emergency assistance project budget at year (t-2)	0.00029
66	Number of agriculture project at year (t-2)	0.000281

North Eastern Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
67	Environment project budget at year (t-1)	0.000276
68	Governance project budget at year (t-2)	0.000273
69	Number of gender project at year (t-1)	0.000269
70	Number of security project at year (t-2)	0.000266
71	Energy project budget at year (t-2)	0.000264
72	Governance project budget at year (t-1)	0.000248
73	Number of emergency assistance project at year (t-2)	0.000247
74	Number of security project at year (t-1)	0.000244
75	Number of governance project at year (t)	0.000231
76	Emergency assistance project budget at year (t-1)	0.000228
77	Commerce and industry project budget at year (t)	0.000227
78	Gender project budget at year (t-2)	0.000221
79	Number of energy project at year (t-2)	0.000219
80	Number of health project at year (t-2)	0.000177
81	Number of governance project at year (t-1)	0.000167
82	Number of water and sanitation project at year (t-2)	0.000166
83	Transport project budget at year (t-1)	0.000164
84	Number of transport project at year (t)	0.000155
85	Water and sanitation project budget at year (t-2)	0.000122
86	Environment project budget at year (t)	0.00012
87	Number of capacity building project at year (t-1)	0.000119
88	Transport project budget at year (t-2)	8.11E-05
89	Education project budget at year (t-1)	7.69E-05

Table 97: The sensitivity rank of all input values for number of people killed in north western region

North Western Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
1	Urban male population density	0.011177
2	Community development project budget at year (t-2)	0.010526
3	Transport project budget at year (t-1)	0.010471
4	Number of agriculture project at year (t-1)	0.010421
5	Number of gender project at year (t-1)	0.010082
6	Education project budget at year (t-1)	0.009304
7	Number of commerce and industry project at year (t-2)	0.008592
8	Number of water and sanitation project at year (t-2)	0.008578
9	Rural male population density	0.008494
10	Number of security project at year (t-1)	0.008179
11	Gender project budget at year (t-1)	0.008118

North Western Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
12	Number of gender project at year (t-2)	0.007365
13	Health project budget at year (t-1)	0.005913
14	Urban female population density	0.005901
15	Number of water and sanitation project at year (t-1)	0.005546
16	Number of people killed at month (t-1)	0.005508
17	Agriculture project budget at year (t-2)	0.005489
18	Number of gender project at year (t)	0.00548
19	Community development project budget at year (t-1)	0.005358
20	Capacity building project budget at year (t-1)	0.00526
21	Number of Community development project at year (t)	0.00503
22	Number of energy project at year (t)	0.005023
23	Number of transport project at year (t-2)	0.005008
24	Agriculture project budget at year (t)	0.004517
25	Capacity building project budget at year (t)	0.004489
26	Number of security project at year (t-2)	0.004416
27	Number of Community development project at year (t-1)	0.004374
28	Number of environment project at year (t-2)	0.004194
29	Number of capacity building project at year (t-2)	0.004077
30	Number of commerce and industry project at year (t)	0.003927
31	Number of governance project at year (t-2)	0.003918
32	Number of commerce and industry project at year (t-1)	0.003905
33	Security project budget at year (t-2)	0.003664
34	Water and sanitation project budget at year (t-1)	0.003597
35	Security project budget at year (t)	0.003416
36	Number of Community development project at year (t-2)	0.003266
37	Number of education project at year (t-1)	0.00324
38	Number of health project at year (t-1)	0.003144
39	Number of energy project at year (t-1)	0.002951
40	Energy project budget at year (t-1)	0.0029
41	Commerce and industry project budget at year (t-2)	0.002814
42	Security project budget at year (t-1)	0.002806
43	Number of transport project at year (t)	0.002671
44	Number of agriculture project at year (t-2)	0.002658
45	Number of agriculture project at year (t)	0.002538
46	Number of water and sanitation project at year (t)	0.002078
47	Commerce and industry project budget at year (t-1)	0.00201
48	Energy project budget at year (t-2)	0.002001
49	Agriculture project budget at year (t-1)	0.001972
50	Number of education project at year (t-2)	0.001937
51	Governance project budget at year (t-1)	0.001929

North Western Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
52	Education project budget at year (t)	0.001892
53	Gender project budget at year (t-2)	0.001733
54	Number of security project at year (t)	0.001671
55	Transport project budget at year (t)	0.001669
56	Rural female population density	0.001556
57	Number of governance project at year (t-1)	0.001483
58	Number of capacity building project at year (t-1)	0.00147
59	Number of education project at year (t)	0.001431
60	Commerce and industry project budget at year (t)	0.001405
61	Number of capacity building project at year (t)	0.001377
62	Governance project budget at year (t)	0.001358
63	Health project budget at year (t-2)	0.001316
64	Number of transport project at year (t-1)	0.001231
65	Environment project budget at year (t)	0.001212
66	Number of health project at year (t-2)	0.001169
67	Education project budget at year (t-2)	0.000984
68	Number of health project at year (t)	0.000955
69	Capacity building project budget at year (t-2)	0.000916
70	Energy project budget at year (t)	0.000866
71	Health project budget at year (t)	0.000838
72	Water and sanitation project budget at year (t)	0.000805
73	Gender project budget at year (t)	0.000796
74	Number of environment project at year (t-1)	0.000766
75	Environment project budget at year (t-2)	0.00064
76	Environment project budget at year (t-1)	0.000623
77	Transport project budget at year (t-2)	0.000589
78	Water and sanitation project budget at year (t-2)	0.000563
79	Number of governance project at year (t)	0.000532
80	Emergency assistance project budget at year (t-2)	0.000364
81	Community development project budget at year (t)	0.000259
82	Number of energy project at year (t-2)	0.000226
83	Governance project budget at year (t-2)	0.000126
84	Number of environment project at year (t)	0.000116
85	Number of emergency assistance project at year (t-2)	2.23E-16
86	Emergency assistance project budget at year (t-1)	2.23E-16
87	Number of emergency assistance project at year (t-1)	2.23E-16
88	Emergency assistance project budget at year (t)	2.23E-16
89	Number of emergency assistance project at year (t)	2.23E-16

Table 98: The sensitivity rank of all input values for number of people wounded in north western region

North Western Region – Number of people wounded		
Rank	**Input name**	**Sensitivity value**
1	Number of agriculture project at year (t-2)	0.015252
2	Transport project budget at year (t)	0.014206
3	Security project budget at year (t-1)	0.013464
4	Number of water and sanitation project at year (t-1)	0.013257
5	Number of transport project at year (t-1)	0.012735
6	Number of energy project at year (t-2)	0.012594
7	Number of emergency assistance project at year (t-2)	0.012483
8	Agriculture project budget at year (t-2)	0.012339
9	Rural male population density	0.011769
10	Gender project budget at year (t-1)	0.011581
11	Environment project budget at year (t-1)	0.011492
12	Number of security project at year (t-1)	0.010755
13	Education project budget at year (t)	0.009791
14	Rural female population density	0.009477
15	Number of energy project at year (t-1)	0.009102
16	Number of Community development project at year (t)	0.008487
17	Number of gender project at year (t-1)	0.008022
18	Health project budget at year (t-1)	0.007954
19	Capacity building project budget at year (t-2)	0.007721
20	Community development project budget at year (t-2)	0.006688
21	Governance project budget at year (t-1)	0.005988
22	Number of agriculture project at year (t-1)	0.005764
23	Number of governance project at year (t)	0.005749
24	Community development project budget at year (t-1)	0.005052
25	Commerce and industry project budget at year (t-2)	0.004598
26	Number of health project at year (t-1)	0.004581
27	Number of security project at year (t-2)	0.004545
28	Number of health project at year (t-2)	0.004351
29	Governance project budget at year (t)	0.004301
30	Energy project budget at year (t)	0.00421
31	Number of commerce and industry project at year (t)	0.004117
32	Education project budget at year (t-2)	0.004025
33	Number of people wounded at month (t-1)	0.003976
34	Number of capacity building project at year (t-2)	0.00389
35	Health project budget at year (t-2)	0.00389
36	Number of capacity building project at year (t)	0.003796
37	Number of transport project at year (t)	0.003623
38	Capacity building project budget at year (t)	0.003523

North Western Region – Number of people wounded		
Rank	**Input name**	**Sensitivity value**
39	Governance project budget at year (t-2)	0.003476
40	Number of energy project at year (t)	0.003427
41	Number of gender project at year (t-2)	0.003317
42	Number of security project at year (t)	0.003311
43	Number of water and sanitation project at year (t)	0.003304
44	Gender project budget at year (t-2)	0.003166
45	Number of capacity building project at year (t-1)	0.002943
46	Transport project budget at year (t-2)	0.002822
47	Number of environment project at year (t)	0.002793
48	Gender project budget at year (t)	0.00271
49	Number of agriculture project at year (t)	0.002609
50	Number of education project at year (t-1)	0.002566
51	Environment project budget at year (t-2)	0.002548
52	Education project budget at year (t-1)	0.002523
53	Urban male population density	0.002496
54	Number of commerce and industry project at year (t-2)	0.002405
55	Number of Community development project at year (t-1)	0.002255
56	Energy project budget at year (t-2)	0.00223
57	Number of environment project at year (t-1)	0.002193
58	Number of health project at year (t)	0.002169
59	Number of environment project at year (t-2)	0.002111
60	Emergency assistance project budget at year (t-2)	0.002047
61	Number of water and sanitation project at year (t-2)	0.001822
62	Number of transport project at year (t-2)	0.001821
63	Security project budget at year (t-2)	0.001773
64	Water and sanitation project budget at year (t-2)	0.00173
65	Urban female population density	0.001634
66	Number of Community development project at year (t-2)	0.001622
67	Number of gender project at year (t)	0.001567
68	Water and sanitation project budget at year (t)	0.001451
69	Health project budget at year (t)	0.001399
70	Commerce and industry project budget at year (t-1)	0.001193
71	Number of governance project at year (t-2)	0.001048
72	Security project budget at year (t)	0.001008
73	Water and sanitation project budget at year (t-1)	0.000956
74	Agriculture project budget at year (t)	0.000898
75	Transport project budget at year (t-1)	0.000873
76	Number of education project at year (t-2)	0.000607
77	Number of governance project at year (t-1)	0.000538
78	Energy project budget at year (t-1)	0.000538

North Western Region – Number of people wounded		
Rank	**Input name**	**Sensitivity value**
79	Number of commerce and industry project at year (t-1)	0.000492
80	Community development project budget at year (t)	0.000467
81	Capacity building project budget at year (t-1)	0.000426
82	Environment project budget at year (t)	0.000305
83	Number of education project at year (t)	0.000282
84	Agriculture project budget at year (t-1)	0.000222
85	Commerce and industry project budget at year (t)	2.97E-05
86	Emergency assistance project budget at year (t-1)	5.58E-17
87	Number of emergency assistance project at year (t-1)	5.58E-17
88	Emergency assistance project budget at year (t)	5.58E-17
89	Number of emergency assistance project at year (t)	5.58E-17

Table 99: The sensitivity rank of all input values for number of people hijacked in north western region

North Western Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
1	Community development project budget at year (t)	0.009188
2	Community development project budget at year (t-1)	0.008988
3	Governance project budget at year (t)	0.008779
4	Governance project budget at year (t-2)	0.007742
5	Governance project budget at year (t-1)	0.007437
6	Community development project budget at year (t-2)	0.006494
7	Number of health project at year (t-2)	0.005285
8	Capacity building project budget at year (t-2)	0.005138
9	Commerce and industry project budget at year (t-2)	0.004747
10	Number of people hijacked at month (t-1)	0.004496
11	Transport project budget at year (t)	0.004406
12	Commerce and industry project budget at year (t)	0.004383
13	Transport project budget at year (t-1)	0.004245
14	Energy project budget at year (t-2)	0.004092
15	Number of health project at year (t-1)	0.004051
16	Number of environment project at year (t)	0.004019
17	Commerce and industry project budget at year (t-1)	0.003944
18	Urban female population density	0.003905
19	Water and sanitation project budget at year (t)	0.00388
20	Agriculture project budget at year (t-2)	0.003877
21	Number of emergency assistance project at year (t-2)	0.003821

North Western Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
22	Education project budget at year (t-2)	0.003814
23	Number of education project at year (t-2)	0.003773
24	Energy project budget at year (t-1)	0.00366
25	Number of energy project at year (t-1)	0.003647
26	Number of transport project at year (t-2)	0.00363
27	Emergency assistance project budget at year (t-2)	0.003594
28	Transport project budget at year (t-2)	0.003589
29	Water and sanitation project budget at year (t-2)	0.003488
30	Agriculture project budget at year (t)	0.003403
31	Urban male population density	0.003395
32	Number of water and sanitation project at year (t)	0.00332
33	Number of energy project at year (t)	0.003301
34	Energy project budget at year (t)	0.00326
35	Number of water and sanitation project at year (t-1)	0.003193
36	Number of commerce and industry project at year (t-2)	0.003178
37	Number of commerce and industry project at year (t)	0.003178
38	Number of water and sanitation project at year (t-2)	0.003141
39	Education project budget at year (t-1)	0.003123
40	Capacity building project budget at year (t)	0.003098
41	Rural male population density	0.003092
42	Number of commerce and industry project at year (t-1)	0.003085
43	Education project budget at year (t)	0.003071
44	Number of environment project at year (t-2)	0.003069
45	Environment project budget at year (t-2)	0.00306
46	Water and sanitation project budget at year (t-1)	0.003054
47	Number of transport project at year (t)	0.003034
48	Number of security project at year (t)	0.003028
49	Number of gender project at year (t)	0.00301
50	Security project budget at year (t-1)	0.003003
51	Number of transport project at year (t-1)	0.002961
52	Number of energy project at year (t-2)	0.002933
53	Gender project budget at year (t)	0.002931
54	Capacity building project budget at year (t-1)	0.002898
55	Number of environment project at year (t-1)	0.00287
56	Number of governance project at year (t-2)	0.002856
57	Number of gender project at year (t-1)	0.002839
58	Number of gender project at year (t-2)	0.002838
59	Number of security project at year (t-2)	0.002832
60	Security project budget at year (t-2)	0.002829
61	Gender project budget at year (t-1)	0.002809

North Western Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
62	Agriculture project budget at year (t-1)	0.002804
63	Number of capacity building project at year (t)	0.0028
64	Environment project budget at year (t-1)	0.002788
65	Number of security project at year (t-1)	0.002784
66	Security project budget at year (t)	0.002768
67	Environment project budget at year (t)	0.002739
68	Number of capacity building project at year (t-1)	0.002711
69	Number of agriculture project at year (t)	0.002687
70	Number of education project at year (t)	0.002686
71	Number of health project at year (t)	0.002683
72	Number of Community development project at year (t-1)	0.002641
73	Number of capacity building project at year (t-2)	0.00263
74	Number of Community development project at year (t-2)	0.00259
75	Gender project budget at year (t-2)	0.002582
76	Number of governance project at year (t-1)	0.002558
77	Health project budget at year (t)	0.002557
78	Number of education project at year (t-1)	0.002525
79	Health project budget at year (t-2)	0.002322
80	Number of Community development project at year (t)	0.002263
81	Health project budget at year (t-1)	0.002241
82	Number of agriculture project at year (t-2)	0.002198
83	Number of governance project at year (t)	0.00219
84	Rural female population density	0.002027
85	Number of agriculture project at year (t-1)	0.001806
86	Emergency assistance project budget at year (t-1)	2.09E-17
87	Number of emergency assistance project at year (t-1)	2.09E-17
88	Emergency assistance project budget at year (t)	2.09E-17
89	Number of emergency assistance project at year (t)	2.09E-17

Table 100: The sensitivity rank of all input values for total number of adverse events in north western region

North Western Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
1	Community development project budget at year (t)	0.051227
2	Community development project budget at year (t-1)	0.051089

North Western Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
3	Community development project budget at year (t-2)	0.046056
4	Governance project budget at year (t-1)	0.04351
5	Governance project budget at year (t)	0.042327
6	Number of commerce and industry project at year (t-2)	0.041044
7	Number of health project at year (t-2)	0.040988
8	Number of education project at year (t)	0.04095
9	Governance project budget at year (t-2)	0.040899
10	Number of health project at year (t-1)	0.040895
11	Number of education project at year (t-1)	0.040825
12	Number of transport project at year (t-1)	0.040058
13	Number of commerce and industry project at year (t-1)	0.040051
14	Number of health project at year (t)	0.04002
15	Number of education project at year (t-2)	0.039642
16	Number of commerce and industry project at year (t)	0.039569
17	Commerce and industry project budget at year (t-1)	0.039139
18	Environment project budget at year (t-2)	0.038988
19	Agriculture project budget at year (t)	0.038872
20	Number of agriculture project at year (t-2)	0.038421
21	Agriculture project budget at year (t-2)	0.038348
22	Number of gender project at year (t)	0.038345
23	Number of Community development project at year (t-2)	0.038308
24	Number of transport project at year (t-2)	0.038248
25	Number of gender project at year (t-2)	0.038218
26	Commerce and industry project budget at year (t-2)	0.038144
27	Number of Community development project at year (t-1)	0.038057
28	Number of capacity building project at year (t-1)	0.037999
29	Number of Community development project at year (t)	0.037935
30	Health project budget at year (t-1)	0.037905
31	Security project budget at year (t-1)	0.037827
32	Urban male population density	0.03782
33	Energy project budget at year (t-1)	0.037753
34	Education project budget at year (t-2)	0.037706
35	Number of water and sanitation project at year (t-2)	0.037693
36	Water and sanitation project budget at year (t)	0.037453
37	Security project budget at year (t)	0.037423
38	Commerce and industry project budget at year (t)	0.037355
39	Gender project budget at year (t)	0.037354
40	Urban female population density	0.037229
41	Number of transport project at year (t)	0.037226
42	Number of capacity building project at year (t-2)	0.03715

North Western Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
43	Gender project budget at year (t-1)	0.037144
44	Number of environment project at year (t-2)	0.037138
45	Environment project budget at year (t)	0.037137
46	Water and sanitation project budget at year (t-2)	0.037116
47	Number of capacity building project at year (t)	0.037108
48	Total number of adverse events at month (t-1)	0.037062
49	Number of security project at year (t-2)	0.03702
50	Security project budget at year (t-2)	0.036893
51	Gender project budget at year (t-2)	0.036865
52	Health project budget at year (t)	0.036855
53	Number of security project at year (t)	0.03682
54	Health project budget at year (t-2)	0.036779
55	Number of security project at year (t-1)	0.036736
56	Energy project budget at year (t)	0.036723
57	Education project budget at year (t-1)	0.036672
58	Number of gender project at year (t-1)	0.036623
59	Transport project budget at year (t-2)	0.036603
60	Environment project budget at year (t-1)	0.03643
61	Transport project budget at year (t)	0.036357
62	Number of agriculture project at year (t-1)	0.036238
63	Number of water and sanitation project at year (t)	0.03623
64	Agriculture project budget at year (t-1)	0.036087
65	Energy project budget at year (t-2)	0.036034
66	Number of governance project at year (t-1)	0.036015
67	Water and sanitation project budget at year (t-1)	0.035981
68	Number of governance project at year (t)	0.035618
69	Transport project budget at year (t-1)	0.035522
70	Number of environment project at year (t-1)	0.035503
71	Number of energy project at year (t)	0.035494
72	Education project budget at year (t)	0.035471
73	Number of water and sanitation project at year (t-1)	0.035428
74	Number of energy project at year (t-1)	0.035425
75	Number of energy project at year (t-2)	0.035292
76	Emergency assistance project budget at year (t-2)	0.035274
77	Number of governance project at year (t-2)	0.034999
78	Number of agriculture project at year (t)	0.034808
79	Number of emergency assistance project at year (t-2)	0.034784
80	Number of environment project at year (t)	0.034585
81	Capacity building project budget at year (t-2)	0.032968
82	Capacity building project budget at year (t-1)	0.029816

North Western Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
83	Rural male population density	0.028218
84	Rural female population density	0.027246
85	Capacity building project budget at year (t)	0.025998
86	Emergency assistance project budget at year (t-1)	4.46E-16
87	Number of emergency assistance project at year (t-1)	4.46E-16
88	Emergency assistance project budget at year (t)	4.46E-16
89	Number of emergency assistance project at year (t)	4.46E-16

Table 101: The sensitivity rank of all input values for number of people killed in south eastern region

South Eastern Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
1	Number of people killed at month (t-1)	1.389431
2	Number of agriculture project at year (t-2)	0.433873
3	Number of commerce and industry project at year (t-2)	0.289306
4	Gender project budget at year (t-1)	0.246394
5	Number of governance project at year (t-1)	0.220795
6	Number of agriculture project at year (t)	0.210171
7	Urban female population density	0.203903
8	Number of energy project at year (t)	0.181772
9	Energy project budget at year (t)	0.169638
10	Health project budget at year (t-2)	0.162925
11	Number of environment project at year (t-1)	0.147976
12	Number of education project at year (t)	0.136615
13	Energy project budget at year (t-2)	0.133014
14	Number of energy project at year (t-2)	0.131117
15	Governance project budget at year (t-2)	0.12602
16	Rural female population density	0.114451
17	Number of transport project at year (t)	0.113406
18	Emergency assistance project budget at year (t)	0.111323
19	Number of commerce and industry project at year (t)	0.109043
20	Education project budget at year (t-1)	0.107364
21	Gender project budget at year (t)	0.09921
22	Community development project budget at year (t)	0.089237
23	Water and sanitation project budget at year (t)	0.08549
24	Number of water and sanitation project at year (t-2)	0.084397
25	Agriculture project budget at year (t-1)	0.081209

South Eastern Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
26	Number of Community development project at year (t-2)	0.0775
27	Number of water and sanitation project at year (t-1)	0.074076
28	Energy project budget at year (t-1)	0.073864
29	Capacity building project budget at year (t)	0.07352
30	Environment project budget at year (t-2)	0.072553
31	Number of health project at year (t-2)	0.069217
32	Urban male population density	0.066874
33	Governance project budget at year (t-1)	0.066393
34	Gender project budget at year (t-2)	0.06626
35	Number of Community development project at year (t-1)	0.065282
36	Number of governance project at year (t-2)	0.064727
37	Transport project budget at year (t)	0.062226
38	Number of environment project at year (t-2)	0.061122
39	Commerce and industry project budget at year (t)	0.059523
40	Education project budget at year (t)	0.058873
41	Transport project budget at year (t-2)	0.058314
42	Number of gender project at year (t)	0.05669
43	Water and sanitation project budget at year (t-1)	0.055283
44	Community development project budget at year (t-1)	0.054472
45	Number of Community development project at year (t)	0.053159
46	Commerce and industry project budget at year (t-1)	0.051427
47	Security project budget at year (t-1)	0.05105
48	Rural male population density	0.050671
49	Education project budget at year (t-2)	0.048232
50	Governance project budget at year (t)	0.045183
51	Number of energy project at year (t-1)	0.044327
52	Number of security project at year (t-1)	0.043478
53	Number of capacity building project at year (t-1)	0.039547
54	Number of capacity building project at year (t)	0.038437
55	Number of transport project at year (t-2)	0.037655
56	Number of health project at year (t)	0.037519
57	Number of environment project at year (t)	0.035439
58	Capacity building project budget at year (t-2)	0.033316
59	Number of capacity building project at year (t-2)	0.032005
60	Number of emergency assistance project at year (t)	0.031901
61	Number of transport project at year (t-1)	0.031058
62	Number of emergency assistance project at year (t-2)	0.029731
63	Health project budget at year (t)	0.029024
64	Environment project budget at year (t-1)	0.028933
65	Number of gender project at year (t-1)	0.028494

South Eastern Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
66	Emergency assistance project budget at year (t-1)	0.027895
67	Number of commerce and industry project at year (t-1)	0.027057
68	Number of education project at year (t-2)	0.024994
69	Water and sanitation project budget at year (t-2)	0.024718
70	Number of security project at year (t-2)	0.024094
71	Number of emergency assistance project at year (t-1)	0.020087
72	Number of security project at year (t)	0.018095
73	Number of governance project at year (t)	0.016285
74	Community development project budget at year (t-2)	0.015743
75	Number of water and sanitation project at year (t)	0.0156
76	Transport project budget at year (t-1)	0.015147
77	Environment project budget at year (t)	0.01426
78	Number of health project at year (t-1)	0.013597
79	Emergency assistance project budget at year (t-2)	0.013235
80	Number of agriculture project at year (t-1)	0.010547
81	Security project budget at year (t)	0.009508
82	Capacity building project budget at year (t-1)	0.00824
83	Number of gender project at year (t-2)	0.007839
84	Agriculture project budget at year (t-2)	0.006833
85	Commerce and industry project budget at year (t-2)	0.006769
86	Health project budget at year (t-1)	0.004678
87	Number of education project at year (t-1)	0.004461
88	Security project budget at year (t-2)	0.004195
89	Agriculture project budget at year (t)	0.002462

Table 102: The sensitivity rank of all input values for number of people wounded in south eastern region

South Eastern Region – Number of people wounded		
Rank	**Input name**	**Sensitivity value**
1	Number of education project at year (t-1)	0.061985
2	Number of capacity building project at year (t-1)	0.038217
3	Health project budget at year (t)	0.036357
4	Number of energy project at year (t-1)	0.036065
5	Water and sanitation project budget at year (t)	0.035609
6	Security project budget at year (t-1)	0.035253
7	Number of gender project at year (t-1)	0.033768
8	Urban female population density	0.033461

South Eastern Region – Number of people wounded		
Rank	**Input name**	**Sensitivity value**
9	Number of education project at year (t-2)	0.033258
10	Number of security project at year (t-2)	0.032605
11	Number of health project at year (t)	0.03218
12	Environment project budget at year (t-2)	0.032097
13	Number of water and sanitation project at year (t-2)	0.031144
14	Agriculture project budget at year (t-2)	0.030277
15	Number of commerce and industry project at year (t-1)	0.02895
16	Energy project budget at year (t)	0.028595
17	Security project budget at year (t)	0.028437
18	Environment project budget at year (t-1)	0.027839
19	Number of emergency assistance project at year (t-2)	0.027444
20	Number of water and sanitation project at year (t-1)	0.027175
21	Emergency assistance project budget at year (t)	0.026351
22	Number of capacity building project at year (t-2)	0.025971
23	Agriculture project budget at year (t-1)	0.025141
24	Number of Community development project at year (t-1)	0.025072
25	Water and sanitation project budget at year (t-2)	0.0244
26	Number of Community development project at year (t)	0.024122
27	Number of transport project at year (t)	0.02357
28	Number of agriculture project at year (t-1)	0.021615
29	Number of governance project at year (t-1)	0.021591
30	Commerce and industry project budget at year (t-1)	0.021585
31	Governance project budget at year (t)	0.021019
32	Number of education project at year (t)	0.020843
33	Emergency assistance project budget at year (t-1)	0.020692
34	Urban male population density	0.020402
35	Number of governance project at year (t-2)	0.020059
36	Gender project budget at year (t-1)	0.019318
37	Number of agriculture project at year (t-2)	0.019224
38	Community development project budget at year (t)	0.018848
39	Governance project budget at year (t-1)	0.018575
40	Energy project budget at year (t-2)	0.01837
41	Number of emergency assistance project at year (t-1)	0.017521
42	Commerce and industry project budget at year (t)	0.016758
43	Number of energy project at year (t-2)	0.016579
44	Security project budget at year (t-2)	0.016362
45	Number of gender project at year (t-2)	0.01569
46	Agriculture project budget at year (t)	0.014964
47	Community development project budget at year (t-1)	0.014815
48	Number of environment project at year (t-1)	0.014178

South Eastern Region – Number of people wounded		
Rank	**Input name**	**Sensitivity value**
49	Community development project budget at year (t-2)	0.013821
50	Number of emergency assistance project at year (t)	0.012857
51	Number of transport project at year (t-2)	0.012397
52	Water and sanitation project budget at year (t-1)	0.012196
53	Number of transport project at year (t-1)	0.012117
54	Energy project budget at year (t-1)	0.012027
55	Gender project budget at year (t)	0.01194
56	Health project budget at year (t-1)	0.011825
57	Environment project budget at year (t)	0.011724
58	Gender project budget at year (t-2)	0.011219
59	Number of health project at year (t-1)	0.010381
60	Number of health project at year (t-2)	0.010045
61	Rural female population density	0.009947
62	Commerce and industry project budget at year (t-2)	0.009758
63	Number of water and sanitation project at year (t)	0.009218
64	Transport project budget at year (t-1)	0.007753
65	Governance project budget at year (t-2)	0.006831
66	Rural male population density	0.006789
67	Number of capacity building project at year (t)	0.006497
68	Number of environment project at year (t)	0.006347
69	Number of commerce and industry project at year (t-2)	0.006319
70	Number of commerce and industry project at year (t)	0.005983
71	Number of energy project at year (t)	0.005641
72	Number of governance project at year (t)	0.005451
73	Emergency assistance project budget at year (t-2)	0.005226
74	Capacity building project budget at year (t)	0.004719
75	Education project budget at year (t-1)	0.004629
76	Transport project budget at year (t)	0.004604
77	Number of peoplewounded at month (t-1)	0.004079
78	Transport project budget at year (t-2)	0.003979
79	Number of gender project at year (t)	0.003786
80	Education project budget at year (t)	0.003718
81	Number of Community development project at year (t-2)	0.003656
82	Number of security project at year (t-1)	0.003548
83	Number of security project at year (t)	0.002925
84	Number of environment project at year (t-2)	0.00286
85	Capacity building project budget at year (t-2)	0.002711
86	Health project budget at year (t-2)	0.002693
87	Number of agriculture project at year (t)	0.002672
88	Capacity building project budget at year (t-1)	0.002521

South Eastern Region – Number of people wounded		
Rank	**Input name**	**Sensitivity value**
89	Education project budget at year (t-2)	0.000983

Table 103: The sensitivity rank of all input values for number of people hijacked in south eastern region

South Eastern Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
1	Environment project budget at year (t)	0.068832
2	Energy project budget at year (t-1)	0.068308
3	Energy project budget at year (t)	0.067473
4	Number of energy project at year (t-1)	0.066241
5	Water and sanitation project budget at year (t-2)	0.065955
6	Water and sanitation project budget at year (t)	0.065698
7	Environment project budget at year (t-1)	0.064976
8	Energy project budget at year (t-2)	0.064343
9	Number of emergency assistance project at year (t-2)	0.064275
10	Number of energy project at year (t)	0.06412
11	Water and sanitation project budget at year (t-1)	0.064072
12	Number of environment project at year (t)	0.063574
13	Environment project budget at year (t-2)	0.063396
14	Rural male population density	0.063361
15	Rural female population density	0.063019
16	Number of education project at year (t)	0.06292
17	Transport project budget at year (t-1)	0.062348
18	Security project budget at year (t-1)	0.06141
19	Number of education project at year (t-1)	0.060628
20	Transport project budget at year (t)	0.0605
21	Number of water and sanitation project at year (t-2)	0.060389
22	Number of energy project at year (t-2)	0.060283
23	Number of water and sanitation project at year (t-1)	0.060265
24	Health project budget at year (t)	0.060166
25	Number of emergency assistance project at year (t-1)	0.059945
26	Number of education project at year (t-2)	0.059931
27	Security project budget at year (t)	0.059589
28	Urban female population density	0.058921
29	Emergency assistance project budget at year (t-1)	0.058745
30	Education project budget at year (t)	0.058188
31	Gender project budget at year (t-2)	0.058019

South Eastern Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
32	Number of people hijacked at month (t-1)	0.057959
33	Community development project budget at year (t-1)	0.057908
34	Number of environment project at year (t-2)	0.057473
35	Community development project budget at year (t-2)	0.057297
36	Number of security project at year (t-1)	0.057135
37	Number of emergency assistance project at year (t)	0.057096
38	Urban male population density	0.057054
39	Emergency assistance project budget at year (t-2)	0.056917
40	Number of environment project at year (t-1)	0.056879
41	Number of transport project at year (t)	0.056847
42	Number of gender project at year (t-1)	0.056692
43	Gender project budget at year (t-1)	0.056527
44	Number of health project at year (t)	0.056271
45	Community development project budget at year (t)	0.056257
46	Security project budget at year (t-2)	0.055964
47	Number of capacity building project at year (t-2)	0.055875
48	Number of gender project at year (t)	0.055856
49	Number of gender project at year (t-2)	0.055653
50	Gender project budget at year (t)	0.055623
51	Number of commerce and industry project at year (t)	0.055485
52	Number of water and sanitation project at year (t)	0.05529
53	Emergency assistance project budget at year (t)	0.055233
54	Agriculture project budget at year (t-1)	0.054729
55	Number of capacity building project at year (t-1)	0.054259
56	Number of security project at year (t)	0.053977
57	Agriculture project budget at year (t-2)	0.053323
58	Number of commerce and industry project at year (t-1)	0.052982
59	Number of agriculture project at year (t)	0.05278
60	Number of security project at year (t-2)	0.052074
61	Agriculture project budget at year (t)	0.051361
62	Number of capacity building project at year (t)	0.051245
63	Education project budget at year (t-1)	0.051182
64	Number of transport project at year (t-1)	0.050998
65	Number of health project at year (t-1)	0.050397
66	Number of transport project at year (t-2)	0.050151
67	Governance project budget at year (t-1)	0.049015
68	Number of commerce and industry project at year (t-2)	0.048612
69	Health project budget at year (t-1)	0.048192
70	Governance project budget at year (t)	0.045649
71	Number of agriculture project at year (t-1)	0.043958

South Eastern Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
72	Health project budget at year (t-2)	0.042535
73	Education project budget at year (t-2)	0.040291
74	Transport project budget at year (t-2)	0.04002
75	Commerce and industry project budget at year (t)	0.039115
76	Number of governance project at year (t)	0.038661
77	Number of health project at year (t-2)	0.038575
78	Capacity building project budget at year (t-2)	0.037539
79	Number of agriculture project at year (t-2)	0.036661
80	Commerce and industry project budget at year (t-2)	0.034245
81	Governance project budget at year (t-2)	0.034171
82	Number of governance project at year (t-1)	0.033909
83	Number of Community development project at year (t-2)	0.032804
84	Commerce and industry project budget at year (t-1)	0.031585
85	Number of Community development project at year (t)	0.031282
86	Number of governance project at year (t-2)	0.030348
87	Number of Community development project at year (t-1)	0.029384
88	Capacity building project budget at year (t-1)	0.025666
89	Capacity building project budget at year (t)	0.022397

Table 104: The sensitivity rank of all input values for total number of adverse events in south eastern region

South Eastern Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
1	Total number of adverse events at month (t-1)	3.793312
2	Number of agriculture project at year (t-2)	0.28758
3	Number of water and sanitation project at year (t)	0.126279
4	Environment project budget at year (t-2)	0.114348
5	Health project budget at year (t-1)	0.10964
6	Urban female population density	0.090584
7	Community development project budget at year (t-2)	0.086602
8	Gender project budget at year (t-1)	0.069209
9	Environment project budget at year (t-1)	0.067098
10	Governance project budget at year (t-2)	0.06284
11	Gender project budget at year (t)	0.061028
12	Urban male population density	0.059765

South Eastern Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
13	Number of commerce and industry project at year (t)	0.053883
14	Number of education project at year (t-2)	0.04893
15	Number of health project at year (t)	0.048155
16	Number of agriculture project at year (t)	0.045529
17	Number of agriculture project at year (t-1)	0.045129
18	Number of Community development project at year (t-1)	0.042024
19	Education project budget at year (t-1)	0.04182
20	Commerce and industry project budget at year (t)	0.038373
21	Number of governance project at year (t)	0.037296
22	Number of gender project at year (t)	0.037029
23	Number of governance project at year (t-2)	0.03534
24	Energy project budget at year (t)	0.033861
25	Number of emergency assistance project at year (t-1)	0.027007
26	Number of security project at year (t-2)	0.026377
27	Number of commerce and industry project at year (t-2)	0.025999
28	Number of water and sanitation project at year (t-1)	0.024524
29	Number of capacity building project at year (t-1)	0.023779
30	Transport project budget at year (t-1)	0.023616
31	Number of governance project at year (t-1)	0.023227
32	Number of transport project at year (t-1)	0.022774
33	Number of energy project at year (t-1)	0.022408
34	Emergency assistance project budget at year (t-1)	0.022307
35	Number of security project at year (t-1)	0.021772
36	Community development project budget at year (t)	0.021195
37	Transport project budget at year (t-2)	0.020626
38	Number of water and sanitation project at year (t-2)	0.01876
39	Health project budget at year (t-2)	0.018407
40	Number of capacity building project at year (t-2)	0.015536
41	Number of health project at year (t-2)	0.015526
42	Number of energy project at year (t)	0.015479
43	Health project budget at year (t)	0.015109
44	Governance project budget at year (t-1)	0.015053
45	Number of capacity building project at year (t)	0.014716
46	Security project budget at year (t-1)	0.013985
47	Number of emergency assistance project at year (t-2)	0.01331
48	Emergency assistance project budget at year (t-2)	0.013084
49	Agriculture project budget at year (t-2)	0.013011
50	Environment project budget at year (t)	0.012959
51	Agriculture project budget at year (t)	0.012445
52	Number of gender project at year (t-1)	0.012265

South Eastern Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
53	Number of gender project at year (t-2)	0.012184
54	Commerce and industry project budget at year (t-1)	0.012164
55	Capacity building project budget at year (t-2)	0.011502
56	Governance project budget at year (t)	0.011456
57	Rural female population density	0.011414
58	Education project budget at year (t)	0.011372
59	Gender project budget at year (t-2)	0.011233
60	Number of health project at year (t-1)	0.011084
61	Commerce and industry project budget at year (t-2)	0.010662
62	Capacity building project budget at year (t-1)	0.009207
63	Water and sanitation project budget at year (t)	0.00851
64	Number of transport project at year (t-2)	0.007687
65	Number of emergency assistance project at year (t)	0.007469
66	Number of Community development project at year (t-2)	0.007056
67	Number of environment project at year (t-1)	0.006763
68	Number of energy project at year (t-2)	0.006673
69	Number of Community development project at year (t)	0.006613
70	Security project budget at year (t)	0.006581
71	Security project budget at year (t-2)	0.006484
72	Emergency assistance project budget at year (t)	0.006424
73	Community development project budget at year (t-1)	0.006233
74	Energy project budget at year (t-2)	0.005738
75	Water and sanitation project budget at year (t-2)	0.005402
76	Number of environment project at year (t-2)	0.005269
77	Number of education project at year (t-1)	0.005085
78	Water and sanitation project budget at year (t-1)	0.004901
79	Number of security project at year (t)	0.004745
80	Number of transport project at year (t)	0.004516
81	Energy project budget at year (t-1)	0.004402
82	Education project budget at year (t-2)	0.003969
83	Number of commerce and industry project at year (t-1)	0.003444
84	Number of environment project at year (t)	0.002909
85	Number of education project at year (t)	0.002519
86	Transport project budget at year (t)	0.00234
87	Agriculture project budget at year (t-1)	0.00218
88	Rural male population density	0.001799
89	Capacity building project budget at year (t)	0.001212

Table 105: The sensitivity rank of all input values for number of people killed in south western region

South Western Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
1	Transport project budget at year (t-2)	3.084833
2	Number of gender project at year (t-2)	2.455562
3	Transport project budget at year (t)	2.422338
4	Transport project budget at year (t-1)	2.12202
5	Number of people killed at month (t-1)	2.080188
6	Number of transport project at year (t)	1.885931
7	Number of transport project at year (t-1)	1.503127
8	Number of environment project at year (t-2)	1.44065
9	Number of capacity building project at year (t-2)	0.95301
10	Number of transport project at year (t-2)	0.940204
11	Number of agriculture project at year (t)	0.921484
12	Number of gender project at year (t-1)	0.817225
13	Number of energy project at year (t-2)	0.764913
14	Number of environment project at year (t-1)	0.756358
15	Capacity building project budget at year (t-2)	0.690475
16	Number of water and sanitation project at year (t)	0.664435
17	Number of commerce and industry project at year (t-2)	0.572274
18	Number of governance project at year (t-1)	0.41802
19	Number of commerce and industry project at year (t)	0.411614
20	Number of energy project at year (t)	0.281623
21	Number of governance project at year (t)	0.263968
22	Number of energy project at year (t-1)	0.240523
23	Number of security project at year (t-1)	0.182981
24	Commerce and industry project budget at year (t)	0.174765
25	Number of Community development project at year (t-2)	0.165002
26	Number of health project at year (t-2)	0.150396
27	Education project budget at year (t-2)	0.117618
28	Number of environment project at year (t)	0.11656
29	Number of capacity building project at year (t-1)	0.114116
30	Governance project budget at year (t)	0.099304
31	Number of education project at year (t-1)	0.098136
32	Number of education project at year (t)	0.095892
33	Governance project budget at year (t-1)	0.095807
34	Capacity building project budget at year (t)	0.093656
35	Water and sanitation project budget at year (t-2)	0.092948
36	Energy project budget at year (t-2)	0.090602
37	Energy project budget at year (t-1)	0.090501
38	Security project budget at year (t-2)	0.090454

South Western Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
39	Community development project budget at year (t-2)	0.089294
40	Environment project budget at year (t-2)	0.089008
41	Agriculture project budget at year (t-1)	0.087922
42	Number of water and sanitation project at year (t-1)	0.08715
43	Number of agriculture project at year (t-1)	0.08633
44	Number of security project at year (t-2)	0.084688
45	Security project budget at year (t-1)	0.084325
46	Rural male population density	0.083217
47	Health project budget at year (t-2)	0.083127
48	Education project budget at year (t-1)	0.082426
49	Rural female population density	0.081976
50	Number of security project at year (t)	0.080783
51	Number of capacity building project at year (t)	0.08061
52	Commerce and industry project budget at year (t-1)	0.077694
53	Energy project budget at year (t)	0.077671
54	Number of emergency assistance project at year (t)	0.077224
55	Education project budget at year (t)	0.074619
56	Governance project budget at year (t-2)	0.074251
57	Number of health project at year (t)	0.073478
58	Environment project budget at year (t-1)	0.071187
59	Number of water and sanitation project at year (t-2)	0.070431
60	Number of health project at year (t-1)	0.069533
61	Capacity building project budget at year (t-1)	0.067637
62	Security project budget at year (t)	0.065877
63	Water and sanitation project budget at year (t)	0.065687
64	Urban male population density	0.064462
65	Urban female population density	0.06414
66	Number of Community development project at year (t-1)	0.063945
67	Agriculture project budget at year (t)	0.063636
68	Number of commerce and industry project at year (t-1)	0.063374
69	Number of education project at year (t-2)	0.062487
70	Number of governance project at year (t-2)	0.058268
71	Commerce and industry project budget at year (t-2)	0.051766
72	Water and sanitation project budget at year (t-1)	0.04746
73	Number of Community development project at year (t)	0.033214
74	Number of agriculture project at year (t-2)	0.028679
75	Community development project budget at year (t)	0.017312
76	Community development project budget at year (t-1)	0.006197
77	Agriculture project budget at year (t-2)	0.00415
78	Environment project budget at year (t)	0.002614

South Western Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
79	Health project budget at year (t-1)	0.001739
80	Health project budget at year (t)	6.83E-06
81	Emergency assistance project budget at year (t-2)	6.96E-14
82	Emergency assistance project budget at year (t-1)	6.85E-14
83	Emergency assistance project budget at year (t)	6.5E-14
84	Number of gender project at year (t)	6.22E-14
85	Gender project budget at year (t)	6.2E-14
86	Gender project budget at year (t-1)	5.9E-14
87	Gender project budget at year (t-2)	5.88E-14
88	Number of emergency assistance project at year (t-1)	5.54E-14
89	Number of emergency assistance project at year (t-2)	5.53E-14

Table 106: The sensitivity rank of all input values for number of people wounded in south western region

South Western Region – Number of people wounded		
Rank	**Input name**	**Sensitivity value**
1	Number of people wounded at month (t-1)	4.895096
2	Number of commerce and industry project at year (t)	2.553992
3	Urban female population density	2.080226
4	Urban male population density	1.825173
5	Number of energy project at year (t-1)	0.833386
6	Transport project budget at year (t)	0.271396
7	Transport project budget at year (t-1)	0.211107
8	Number of environment project at year (t-2)	0.148116
9	Number of energy project at year (t-2)	0.080617
10	Number of education project at year (t-2)	0.077008
11	Number of Community development project at year (t-1)	0.037813
12	Number of capacity building project at year (t-2)	0.023069
13	Environment project budget at year (t-1)	0.022435
14	Capacity building project budget at year (t-2)	0.019144

South Western Region – Number of people wounded		
Rank	**Input name**	**Sensitivity value**
15	Number of health project at year (t-2)	0.01652
16	Number of transport project at year (t-1)	0.013036
17	Number of energy project at year (t)	0.009137
18	Number of capacity building project at year (t-1)	0.008725
19	Number of governance project at year (t-1)	0.00838
20	Number of security project at year (t-2)	0.007565
21	Number of environment project at year (t-1)	0.00756
22	Environment project budget at year (t-2)	0.007549
23	Number of gender project at year (t-2)	0.006962
24	Number of education project at year (t-1)	0.00559
25	Number of Community development project at year (t)	0.005502
26	Governance project budget at year (t-1)	0.004716
27	Number of gender project at year (t-1)	0.004565
28	Number of agriculture project at year (t-1)	0.004437
29	Number of commerce and industry project at year (t-1)	0.004229
30	Number of governance project at year (t-2)	0.003981
31	Number of agriculture project at year (t-2)	0.003916
32	Number of emergency assistance project at year (t-2)	0.003857
33	Number of health project at year (t-1)	0.003793
34	Emergency assistance project budget at year (t-2)	0.003711
35	Governance project budget at year (t-2)	0.003039
36	Education project budget at year (t-1)	0.002979
37	Commerce and industry project budget at year (t)	0.002832
38	Agriculture project budget at year (t-1)	0.002685
39	Number of capacity building project at year (t)	0.002378
40	Capacity building project budget at year (t)	0.00227
41	Water and sanitation project budget at year (t-1)	0.002132
42	Number of security project at year (t)	0.002117
43	Number of health project at year (t)	0.001998
44	Number of governance project at year (t)	0.001849
45	Number of Community development project at year (t-2)	0.001746
46	Number of transport project at year (t-2)	0.001524
47	Number of water and sanitation project at year (t-1)	0.001518
48	Community development project budget at year (t-1)	0.001445
49	Education project budget at year (t)	0.001345
50	Governance project budget at year (t)	0.001338
51	Number of transport project at year (t)	0.001333
52	Transport project budget at year (t-2)	0.001318
53	Health project budget at year (t)	0.001285
54	Rural female population density	0.001188

South Western Region – Number of people wounded		
Rank	**Input name**	**Sensitivity value**
55	Number of gender project at year (t)	0.001109
56	Health project budget at year (t-2)	0.00106
57	Environment project budget at year (t)	0.001045
58	Capacity building project budget at year (t-1)	0.000971
59	Commerce and industry project budget at year (t-2)	0.000939
60	Security project budget at year (t-2)	0.000894
61	Number of commerce and industry project at year (t-2)	0.000777
62	Energy project budget at year (t-2)	0.00074
63	Number of education project at year (t)	0.000732
64	Gender project budget at year (t-2)	0.000719
65	Number of security project at year (t-1)	0.000716
66	Security project budget at year (t-1)	0.00068
67	Community development project budget at year (t-2)	0.000657
68	Emergency assistance project budget at year (t)	0.000656
69	Water and sanitation project budget at year (t)	0.000645
70	Number of water and sanitation project at year (t-2)	0.000602
71	Energy project budget at year (t-1)	0.000601
72	Water and sanitation project budget at year (t-2)	0.000592
73	Number of water and sanitation project at year (t)	0.000584
74	Gender project budget at year (t-1)	0.000554
75	Emergency assistance project budget at year (t-1)	0.000505
76	Rural male population density	0.000503
77	Agriculture project budget at year (t-2)	0.000499
78	Number of agriculture project at year (t)	0.00048
79	Health project budget at year (t-1)	0.000446
80	Number of environment project at year (t)	0.000429
81	Security project budget at year (t)	0.000409
82	Education project budget at year (t-2)	0.000406
83	Energy project budget at year (t)	0.000367
84	Number of emergency assistance project at year (t-1)	0.000268
85	Commerce and industry project budget at year (t-1)	0.000214
86	Community development project budget at year (t)	0.000206
87	Agriculture project budget at year (t)	0.00018
88	Gender project budget at year (t)	8.96E-05
89	Number of emergency assistance project at year (t)	5.91E-05

Table 107: The sensitivity rank of all input values for number of people hijacked in south western region

South Western Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
1	Number of health project at year (t-2)	0.026035
2	Number of governance project at year (t-2)	0.025723
3	Number of Community development project at year (t)	0.025593
4	Number of water and sanitation project at year (t)	0.023939
5	Number of security project at year (t)	0.023899
6	Number of commerce and industry project at year (t-2)	0.023435
7	Number of health project at year (t-1)	0.023252
8	Number of education project at year (t-1)	0.021433
9	Number of governance project at year (t)	0.021411
10	Governance project budget at year (t)	0.021384
11	Number of security project at year (t-2)	0.021268
12	Capacity building project budget at year (t-2)	0.020444
13	Transport project budget at year (t-1)	0.019705
14	Education project budget at year (t)	0.019034
15	Number of transport project at year (t-1)	0.019013
16	Capacity building project budget at year (t-1)	0.019003
17	Capacity building project budget at year (t)	0.018741
18	Number of agriculture project at year (t-1)	0.018446
19	Water and sanitation project budget at year (t-1)	0.018271
20	Health project budget at year (t)	0.018011
21	Community development project budget at year (t-2)	0.017985
22	Energy project budget at year (t)	0.017853
23	Number of Community development project at year (t-1)	0.017533
24	Health project budget at year (t-1)	0.017301
25	Number of gender project at year (t)	0.016588
26	Transport project budget at year (t)	0.016256
27	Water and sanitation project budget at year (t-2)	0.016084
28	Agriculture project budget at year (t)	0.01594
29	Education project budget at year (t-1)	0.015714
30	Number of governance project at year (t-1)	0.015645
31	Community development project budget at year (t-1)	0.015615
32	Agriculture project budget at year (t-2)	0.015152
33	Number of gender project at year (t-1)	0.01473
34	Number of capacity building project at year (t-2)	0.014631
35	Community development project budget at year (t)	0.014516
36	Agriculture project budget at year (t-1)	0.014334
37	Commerce and industry project budget at year (t-1)	0.013933
38	Commerce and industry project budget at year (t)	0.013895

South Western Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
39	Number of security project at year (t-1)	0.013874
40	Number of environment project at year (t-2)	0.013829
41	Gender project budget at year (t-1)	0.013609
42	Number of commerce and industry project at year (t-1)	0.013496
43	Security project budget at year (t-2)	0.013385
44	Number of emergency assistance project at year (t-1)	0.013126
45	Number of environment project at year (t-1)	0.013078
46	Commerce and industry project budget at year (t-2)	0.013063
47	Governance project budget at year (t-1)	0.013048
48	Environment project budget at year (t)	0.012928
49	Emergency assistance project budget at year (t-1)	0.012836
50	Number of capacity building project at year (t)	0.012345
51	Rural male population density	0.01223
52	Number of education project at year (t)	0.012111
53	Governance project budget at year (t-2)	0.011952
54	Number of transport project at year (t)	0.01186
55	Number of water and sanitation project at year (t-2)	0.011314
56	Number of environment project at year (t)	0.010887
57	Number of Community development project at year (t-2)	0.010643
58	Energy project budget at year (t-1)	0.010547
59	Emergency assistance project budget at year (t)	0.010427
60	Number of gender project at year (t-2)	0.009975
61	Energy project budget at year (t-2)	0.00978
62	Number of energy project at year (t-1)	0.008814
63	Health project budget at year (t-2)	0.008716
64	Gender project budget at year (t)	0.008651
65	Number of agriculture project at year (t)	0.008648
66	Number of agriculture project at year (t-2)	0.008311
67	Urban male population density	0.00794
68	Transport project budget at year (t-2)	0.00768
69	Education project budget at year (t-2)	0.007433
70	Gender project budget at year (t-2)	0.007388
71	Emergency assistance project budget at year (t-2)	0.007193
72	Number of capacity building project at year (t-1)	0.006837
73	Environment project budget at year (t-1)	0.006388
74	Number of emergency assistance project at year (t-2)	0.006282
75	Number of emergency assistance project at year (t)	0.006228
76	Environment project budget at year (t-2)	0.005602
77	Number of energy project at year (t)	0.005512
78	Urban female population density	0.005362

South Western Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
79	Number of people hijacked at month (t-1)	0.005287
80	Number of health project at year (t)	0.00523
81	Number of water and sanitation project at year (t-1)	0.004292
82	Number of transport project at year (t-2)	0.004039
83	Number of energy project at year (t-2)	0.002662
84	Security project budget at year (t)	0.001982
85	Water and sanitation project budget at year (t)	0.001852
86	Number of education project at year (t-2)	0.001725
87	Rural female population density	0.001446
88	Number of commerce and industry project at year (t)	0.001348
89	Security project budget at year (t-1)	7E-05

Table 108: The sensitivity rank of all input values for total number of adverse events in south western region

South Western Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
1	Total number of adverse events at month (t-1)	1.604101
2	Transport project budget at year (t-2)	0.161334
3	Number of energy project at year (t-1)	0.133354
4	Number of energy project at year (t-2)	0.106567
5	Number of Community development project at year (t-2)	0.100456
6	Number of agriculture project at year (t)	0.09117
7	Transport project budget at year (t-1)	0.090792
8	Number of transport project at year (t-1)	0.089121
9	Number of transport project at year (t-2)	0.088292
10	Number of environment project at year (t-1)	0.083377
11	Number of agriculture project at year (t-2)	0.080833
12	Number of energy project at year (t)	0.078548
13	Number of security project at year (t-2)	0.074374
14	Water and sanitation project budget at year (t)	0.069575
15	Number of commerce and industry project at year (t)	0.06852
16	Number of Community development project at year (t-1)	0.065283
17	Health project budget at year (t-2)	0.05311
18	Commerce and industry project budget at year (t-2)	0.046204
19	Community development project budget at year (t)	0.044688

South Western Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
20	Water and sanitation project budget at year (t-1)	0.04132
21	Number of security project at year (t-1)	0.039013
22	Capacity building project budget at year (t-1)	0.038402
23	Commerce and industry project budget at year (t-1)	0.038307
24	Commerce and industry project budget at year (t)	0.036967
25	Governance project budget at year (t)	0.036403
26	Governance project budget at year (t-2)	0.036328
27	Governance project budget at year (t-1)	0.036298
28	Gender project budget at year (t-2)	0.032588
29	Number of Community development project at year (t)	0.031499
30	Number of gender project at year (t-1)	0.028875
31	Number of governance project at year (t-2)	0.028141
32	Emergency assistance project budget at year (t-1)	0.027455
33	Number of gender project at year (t)	0.026831
34	Number of governance project at year (t-1)	0.026692
35	Number of environment project at year (t)	0.025716
36	Energy project budget at year (t-1)	0.025695
37	Education project budget at year (t-1)	0.024019
38	Capacity building project budget at year (t-2)	0.023797
39	Agriculture project budget at year (t)	0.022652
40	Energy project budget at year (t)	0.022242
41	Environment project budget at year (t)	0.021947
42	Number of health project at year (t-1)	0.021861
43	Water and sanitation project budget at year (t-2)	0.021725
44	Energy project budget at year (t-2)	0.021666
45	Community development project budget at year (t-1)	0.021206
46	Security project budget at year (t)	0.021159
47	Rural male population density	0.020983
48	Urban male population density	0.020644
49	Number of emergency assistance project at year (t)	0.019805
50	Number of capacity building project at year (t-2)	0.019177
51	Number of gender project at year (t-2)	0.018771
52	Number of emergency assistance project at year (t-2)	0.01876
53	Emergency assistance project budget at year (t-2)	0.018279
54	Number of water and sanitation project at year (t-2)	0.01774
55	Number of water and sanitation project at year (t)	0.017421
56	Agriculture project budget at year (t-1)	0.01687
57	Security project budget at year (t-2)	0.016424
58	Number of commerce and industry project at year (t-1)	0.016227
59	Health project budget at year (t)	0.016127

South Western Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
60	Urban female population density	0.015793
61	Number of commerce and industry project at year (t-2)	0.015298
62	Number of capacity building project at year (t-1)	0.014863
63	Security project budget at year (t-1)	0.014175
64	Number of health project at year (t-2)	0.013705
65	Number of capacity building project at year (t)	0.013366
66	Transport project budget at year (t)	0.013203
67	Number of transport project at year (t)	0.012267
68	Agriculture project budget at year (t-2)	0.011703
69	Education project budget at year (t)	0.011033
70	Capacity building project budget at year (t)	0.010581
71	Number of health project at year (t)	0.010162
72	Number of emergency assistance project at year (t-1)	0.009632
73	Community development project budget at year (t-2)	0.009127
74	Number of agriculture project at year (t-1)	0.008893
75	Rural female population density	0.008277
76	Number of education project at year (t)	0.007581
77	Health project budget at year (t-1)	0.006954
78	Number of education project at year (t-1)	0.006749
79	Number of security project at year (t)	0.006701
80	Number of governance project at year (t)	0.006468
81	Number of environment project at year (t-2)	0.005934
82	Number of education project at year (t-2)	0.005625
83	Education project budget at year (t-2)	0.004895
84	Environment project budget at year (t-1)	0.00395
85	Gender project budget at year (t-1)	0.003925
86	Environment project budget at year (t-2)	0.003203
87	Emergency assistance project budget at year (t)	0.002644
88	Number of water and sanitation project at year (t-1)	0.002108
89	Gender project budget at year (t)	0.002052

Table 109: The sensitivity rank of all input values for number of people killed in western region

Western Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
1	Energy project budget at year (t)	0.023188

Western Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
2	Number of environment project at year (t)	0.021783
3	Number of water and sanitation project at year (t-1)	0.019649
4	Number of security project at year (t)	0.017197
5	Gender project budget at year (t-1)	0.017125
6	Water and sanitation project budget at year (t-2)	0.017007
7	Number of agriculture project at year (t-1)	0.016798
8	Number of Community development project at year (t)	0.015282
9	Number of transport project at year (t-2)	0.015238
10	Number of gender project at year (t-2)	0.015107
11	Environment project budget at year (t)	0.014607
12	Health project budget at year (t)	0.014027
13	Governance project budget at year (t-1)	0.013836
14	Water and sanitation project budget at year (t)	0.013398
15	Health project budget at year (t-2)	0.013348
16	Number of energy project at year (t-1)	0.013285
17	Number of people killed at month (t-1)	0.012905
18	Community development project budget at year (t-1)	0.012854
19	Number of gender project at year (t-1)	0.012682
20	Commerce and industry project budget at year (t)	0.012226
21	Rural male population density	0.011666
22	Capacity building project budget at year (t-2)	0.011385
23	Emergency assistance project budget at year (t-2)	0.01082
24	Number of education project at year (t-2)	0.010476
25	Governance project budget at year (t)	0.010296
26	Agriculture project budget at year (t-1)	0.01016
27	Education project budget at year (t-1)	0.010089
28	Number of water and sanitation project at year (t-2)	0.009236
29	Urban female population density	0.008876
30	Number of commerce and industry project at year (t-2)	0.008577
31	Number of commerce and industry project at year (t-1)	0.008461
32	Number of energy project at year (t-2)	0.008379
33	Agriculture project budget at year (t-2)	0.008155
34	Urban male population density	0.007848
35	Number of security project at year (t-1)	0.007705
36	Gender project budget at year (t-2)	0.0075
37	Security project budget at year (t-1)	0.007318
38	Transport project budget at year (t)	0.00718
39	Capacity building project budget at year (t)	0.00715
40	Number of governance project at year (t-1)	0.007092
41	Security project budget at year (t-2)	0.006966

Western Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
42	Capacity building project budget at year (t-1)	0.006866
43	Community development project budget at year (t)	0.006732
44	Number of security project at year (t-2)	0.006601
45	Gender project budget at year (t)	0.006474
46	Transport project budget at year (t-2)	0.006112
47	Commerce and industry project budget at year (t-2)	0.006054
48	Number of health project at year (t-1)	0.005569
49	Number of commerce and industry project at year (t)	0.005454
50	Number of gender project at year (t)	0.005154
51	Number of agriculture project at year (t-2)	0.005089
52	Number of environment project at year (t-1)	0.004929
53	Number of water and sanitation project at year (t)	0.004682
54	Education project budget at year (t-2)	0.004392
55	Number of Community development project at year (t-1)	0.00432
56	Number of capacity building project at year (t-2)	0.004224
57	Number of emergency assistance project at year (t-2)	0.004142
58	Number of emergency assistance project at year (t)	0.00413
59	Number of transport project at year (t-1)	0.003697
60	Health project budget at year (t-1)	0.003589
61	Community development project budget at year (t-2)	0.003304
62	Security project budget at year (t)	0.003269
63	Number of education project at year (t-1)	0.003093
64	Number of Community development project at year (t-2)	0.002941
65	Commerce and industry project budget at year (t-1)	0.002831
66	Environment project budget at year (t-2)	0.002822
67	Agriculture project budget at year (t)	0.002812
68	Transport project budget at year (t-1)	0.002788
69	Rural female population density	0.002651
70	Water and sanitation project budget at year (t-1)	0.002643
71	Environment project budget at year (t-1)	0.002626
72	Energy project budget at year (t-1)	0.002595
73	Number of emergency assistance project at year (t-1)	0.002431
74	Number of health project at year (t-2)	0.002422
75	Number of capacity building project at year (t)	0.002359
76	Number of energy project at year (t)	0.002101
77	Number of agriculture project at year (t)	0.0021
78	Number of environment project at year (t-2)	0.002072
79	Education project budget at year (t)	0.002031
80	Number of governance project at year (t)	0.001613
81	Number of health project at year (t)	0.001571

Western Region – Number of people killed		
Rank	**Input name**	**Sensitivity value**
82	Number of governance project at year (t-2)	0.001479
83	Number of education project at year (t)	0.001464
84	Governance project budget at year (t-2)	0.001462
85	Number of transport project at year (t)	0.001126
86	Emergency assistance project budget at year (t)	0.000699
87	Emergency assistance project budget at year (t-1)	0.000617
88	Energy project budget at year (t-2)	0.00042
89	Number of capacity building project at year (t-1)	0.000182

Table 110: The sensitivity rank of all input values for number of people wounded in western region

Western Region – Number of people wounded		
Rank	**Input name**	**Sensitivity value**
1	Number of people wounded at month (t-1)	0.032976
2	Number of health project at year (t)	0.026347
3	Number of commerce and industry project at year (t)	0.024151
4	Number of capacity building project at year (t-2)	0.018416
5	Number of agriculture project at year (t-1)	0.015701
6	Number of Community development project at year (t)	0.015204
7	Number of transport project at year (t-2)	0.013509
8	Number of security project at year (t-2)	0.011099
9	Number of transport project at year (t-1)	0.011039
10	Number of commerce and industry project at year (t-1)	0.01075
11	Capacity building project budget at year (t-2)	0.010565
12	Number of water and sanitation project at year (t-1)	0.010335
13	Number of governance project at year (t-1)	0.010114
14	Energy project budget at year (t-2)	0.009723
15	Transport project budget at year (t-2)	0.009474
16	Education project budget at year (t-2)	0.0094
17	Number of energy project at year (t-2)	0.009163
18	Number of commerce and industry project at year (t-2)	0.008507
19	Number of capacity building project at year (t-1)	0.008269
20	Emergency assistance project budget at year (t-2)	0.007659
21	Commerce and industry project budget at year (t-1)	0.007654
22	Number of gender project at year (t-2)	0.007532

Western Region – Number of people wounded		
Rank	**Input name**	**Sensitivity value**
23	Number of agriculture project at year (t-2)	0.007378
24	Environment project budget at year (t-2)	0.00732
25	Agriculture project budget at year (t)	0.007241
26	Number of governance project at year (t-2)	0.007167
27	Water and sanitation project budget at year (t)	0.00712
28	Number of security project at year (t-1)	0.006883
29	Agriculture project budget at year (t-1)	0.006732
30	Number of education project at year (t-1)	0.006632
31	Number of environment project at year (t)	0.006314
32	Health project budget at year (t-1)	0.004864
33	Gender project budget at year (t-1)	0.004815
34	Education project budget at year (t)	0.004734
35	Governance project budget at year (t-2)	0.004725
36	Number of environment project at year (t-1)	0.004525
37	Number of emergency assistance project at year (t-1)	0.004481
38	Number of transport project at year (t)	0.004338
39	Number of gender project at year (t-1)	0.004321
40	Transport project budget at year (t-1)	0.004008
41	Number of health project at year (t-2)	0.003976
42	Community development project budget at year (t-2)	0.003825
43	Energy project budget at year (t)	0.003816
44	Number of water and sanitation project at year (t)	0.0038
45	Transport project budget at year (t)	0.003723
46	Commerce and industry project budget at year (t-2)	0.003684
47	Number of environment project at year (t-2)	0.003514
48	Community development project budget at year (t-1)	0.003276
49	Urban female population density	0.003204
50	Number of energy project at year (t)	0.003141
51	Number of emergency assistance project at year (t-2)	0.002844
52	Number of education project at year (t)	0.002734
53	Energy project budget at year (t-1)	0.00254
54	Community development project budget at year (t)	0.002378
55	Number of capacity building project at year (t)	0.002375
56	Number of security project at year (t)	0.002373
57	Governance project budget at year (t-1)	0.002369
58	Security project budget at year (t)	0.002359
59	Number of gender project at year (t)	0.002085
60	Number of governance project at year (t)	0.002005
61	Rural male population density	0.001997
62	Number of health project at year (t-1)	0.001962

Western Region – Number of people wounded		
Rank	**Input name**	**Sensitivity value**
63	Number of emergency assistance project at year (t)	0.001798
64	Urban male population density	0.00167
65	Capacity building project budget at year (t-1)	0.001642
66	Number of Community development project at year (t-1)	0.001567
67	Emergency assistance project budget at year (t)	0.001546
68	Capacity building project budget at year (t)	0.001546
69	Number of energy project at year (t-1)	0.001395
70	Number of water and sanitation project at year (t-2)	0.001334
71	Health project budget at year (t-2)	0.001201
72	Water and sanitation project budget at year (t-1)	0.001193
73	Emergency assistance project budget at year (t-1)	0.001015
74	Gender project budget at year (t-2)	0.000908
75	Commerce and industry project budget at year (t)	0.000902
76	Environment project budget at year (t-1)	0.000898
77	Security project budget at year (t-1)	0.000848
78	Education project budget at year (t-1)	0.000732
79	Rural female population density	0.000602
80	Security project budget at year (t-2)	0.000549
81	Agriculture project budget at year (t-2)	0.000502
82	Health project budget at year (t)	0.000479
83	Number of Community development project at year (t-2)	0.000464
84	Gender project budget at year (t)	0.000443
85	Environment project budget at year (t)	0.000366
86	Water and sanitation project budget at year (t-2)	0.000213
87	Number of agriculture project at year (t)	0.000206
88	Number of education project at year (t-2)	0.000152
89	Governance project budget at year (t)	2.4E-05

Table 111: The sensitivity rank of all input values for number of people hijacked in western region

Western Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
1	Energy project budget at year (t-2)	0.035361
2	Number of commerce and industry project at year (t-2)	0.031084
3	Transport project budget at year (t)	0.027841
4	Number of energy project at year (t)	0.024136
5	Community development project budget at year (t-1)	0.023968

Western Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
6	Energy project budget at year (t-1)	0.02119
7	Number of emergency assistance project at year (t)	0.020937
8	Number of capacity building project at year (t)	0.020603
9	Emergency assistance project budget at year (t)	0.019567
10	Number of gender project at year (t-1)	0.016376
11	Education project budget at year (t-2)	0.014538
12	Number of transport project at year (t-1)	0.013089
13	Transport project budget at year (t-2)	0.011991
14	Health project budget at year (t-1)	0.009657
15	Governance project budget at year (t-2)	0.009403
16	Gender project budget at year (t-1)	0.007939
17	Agriculture project budget at year (t-2)	0.007936
18	Number of environment project at year (t)	0.007907
19	Gender project budget at year (t)	0.007157
20	Environment project budget at year (t)	0.006749
21	Number of transport project at year (t-2)	0.006709
22	Number of commerce and industry project at year (t-1)	0.006353
23	Education project budget at year (t)	0.006098
24	Commerce and industry project budget at year (t-2)	0.005927
25	Number of water and sanitation project at year (t-1)	0.005821
26	Number of education project at year (t)	0.005662
27	Community development project budget at year (t)	0.005379
28	Number of agriculture project at year (t-2)	0.005327
29	Security project budget at year (t)	0.005058
30	Security project budget at year (t-2)	0.004958
31	Rural male population density	0.004927
32	Number of governance project at year (t-2)	0.004345
33	Health project budget at year (t-2)	0.004269
34	Number of people hijacked at month (t-1)	0.004199
35	Number of education project at year (t-1)	0.003808
36	Number of emergency assistance project at year (t-2)	0.003805
37	Number of gender project at year (t-2)	0.003584
38	Environment project budget at year (t-2)	0.003572
39	Number of security project at year (t)	0.003493
40	Number of water and sanitation project at year (t)	0.003458
41	Number of security project at year (t-1)	0.003376
42	Emergency assistance project budget at year (t-1)	0.003246
43	Number of Community development project at year (t-1)	0.00322
44	Commerce and industry project budget at year (t-1)	0.003093
45	Number of health project at year (t)	0.003024

Western Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
46	Number of health project at year (t-2)	0.00302
47	Number of Community development project at year (t-2)	0.002779
48	Water and sanitation project budget at year (t-2)	0.002759
49	Emergency assistance project budget at year (t-2)	0.002702
50	Number of agriculture project at year (t-1)	0.002657
51	Rural female population density	0.002652
52	Number of emergency assistance project at year (t-1)	0.002596
53	Urban female population density	0.002589
54	Number of capacity building project at year (t-1)	0.002521
55	Agriculture project budget at year (t-1)	0.002384
56	Environment project budget at year (t-1)	0.002376
57	Commerce and industry project budget at year (t)	0.002373
58	Gender project budget at year (t-2)	0.002327
59	Governance project budget at year (t-1)	0.002307
60	Urban male population density	0.002263
61	Transport project budget at year (t-1)	0.002262
62	Capacity building project budget at year (t-1)	0.002061
63	Number of capacity building project at year (t-2)	0.002046
64	Security project budget at year (t-1)	0.001879
65	Number of energy project at year (t-1)	0.001769
66	Number of security project at year (t-2)	0.001668
67	Number of energy project at year (t-2)	0.001579
68	Number of Community development project at year (t)	0.001572
69	Health project budget at year (t)	0.001566
70	Number of commerce and industry project at year (t)	0.001522
71	Number of governance project at year (t-1)	0.001499
72	Education project budget at year (t-1)	0.001411
73	Number of health project at year (t-1)	0.001391
74	Number of environment project at year (t-1)	0.001302
75	Water and sanitation project budget at year (t)	0.001263
76	Water and sanitation project budget at year (t-1)	0.001254
77	Energy project budget at year (t)	0.001119
78	Number of gender project at year (t)	0.001108
79	Number of environment project at year (t-2)	0.001077
80	Community development project budget at year (t-2)	0.000958
81	Number of water and sanitation project at year (t-2)	0.000954
82	Number of education project at year (t-2)	0.000931
83	Number of governance project at year (t)	0.00091
84	Agriculture project budget at year (t)	0.00083
85	Number of transport project at year (t)	0.00075

Western Region – Number of people hijacked		
Rank	**Input name**	**Sensitivity value**
86	Governance project budget at year (t)	0.000639
87	Number of agriculture project at year (t)	0.000615
88	Capacity building project budget at year (t)	0.000572
89	Capacity building project budget at year (t-2)	0.000351

Table 112: The sensitivity rank of all input values for total number of adverse events in western region

Western Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
1	Total number of adverse events at month (t-1)	0.508668
2	Number of commerce and industry project at year (t-2)	0.403124
3	Urban male population density	0.376504
4	Urban female population density	0.302096
5	Number of agriculture project at year (t-2)	0.266254
6	Number of Community development project at year (t-2)	0.258661
7	Commerce and industry project budget at year (t-2)	0.255091
8	Number of governance project at year (t-1)	0.247157
9	Transport project budget at year (t-2)	0.240304
10	Governance project budget at year (t)	0.225746
11	Number of capacity building project at year (t-1)	0.223934
12	Energy project budget at year (t-2)	0.208561
13	Number of capacity building project at year (t)	0.198447
14	Emergency assistance project budget at year (t-2)	0.191971
15	Number of agriculture project at year (t-1)	0.191205
16	Number of governance project at year (t-2)	0.183505
17	Number of education project at year (t)	0.17468
18	Gender project budget at year (t)	0.173344
19	Number of gender project at year (t-2)	0.17218
20	Number of Community development project at year (t-1)	0.158295
21	Rural female population density	0.155487
22	Health project budget at year (t)	0.153906
23	Number of transport project at year (t-1)	0.153637
24	Governance project budget at year (t-1)	0.150562
25	Gender project budget at year (t-2)	0.146568
26	Rural male population density	0.14579

Western Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
27	Commerce and industry project budget at year (t)	0.144283
28	Environment project budget at year (t)	0.143986
29	Agriculture project budget at year (t-2)	0.138678
30	Energy project budget at year (t)	0.138643
31	Emergency assistance project budget at year (t-1)	0.138622
32	Energy project budget at year (t-1)	0.138235
33	Emergency assistance project budget at year (t)	0.136087
34	Number of security project at year (t-2)	0.135531
35	Education project budget at year (t)	0.132322
36	Number of gender project at year (t)	0.129438
37	Education project budget at year (t-2)	0.127275
38	Number of security project at year (t-1)	0.126897
39	Water and sanitation project budget at year (t)	0.125031
40	Water and sanitation project budget at year (t-1)	0.120339
41	Capacity building project budget at year (t-2)	0.120164
42	Commerce and industry project budget at year (t-1)	0.111713
43	Environment project budget at year (t-1)	0.109735
44	Number of environment project at year (t-1)	0.105852
45	Number of capacity building project at year (t-2)	0.10556
46	Education project budget at year (t-1)	0.10186
47	Number of emergency assistance project at year (t-1)	0.090853
48	Number of commerce and industry project at year (t-1)	0.090747
49	Community development project budget at year (t-1)	0.088956
50	Number of Community development project at year (t)	0.083938
51	Number of governance project at year (t)	0.083429
52	Capacity building project budget at year (t)	0.07839
53	Health project budget at year (t-2)	0.075949
54	Number of gender project at year (t-1)	0.073824
55	Community development project budget at year (t)	0.073272
56	Number of commerce and industry project at year (t)	0.071751
57	Number of environment project at year (t)	0.071707
58	Community development project budget at year (t-2)	0.069768
59	Number of health project at year (t-2)	0.067911
60	Security project budget at year (t)	0.066371
61	Number of education project at year (t-2)	0.065869
62	Number of emergency assistance project at year (t-2)	0.064113
63	Security project budget at year (t-2)	0.062122
64	Number of transport project at year (t-2)	0.051662
65	Number of emergency assistance project at year (t)	0.05084
66	Agriculture project budget at year (t)	0.050679

Western Region – Total number of adverse events		
Rank	**Input name**	**Sensitivity value**
67	Environment project budget at year (t-2)	0.048825
68	Agriculture project budget at year (t-1)	0.046059
69	Gender project budget at year (t-1)	0.046015
70	Number of water and sanitation project at year (t-1)	0.042688
71	Number of transport project at year (t)	0.041382
72	Number of energy project at year (t)	0.03794
73	Number of agriculture project at year (t)	0.034776
74	Number of water and sanitation project at year (t)	0.034122
75	Transport project budget at year (t-1)	0.033862
76	Number of water and sanitation project at year (t-2)	0.03243
77	Transport project budget at year (t)	0.03174
78	Number of environment project at year (t-2)	0.031135
79	Water and sanitation project budget at year (t-2)	0.029854
80	Number of energy project at year (t-2)	0.029517
81	Security project budget at year (t-1)	0.029211
82	Health project budget at year (t-1)	0.026272
83	Number of security project at year (t)	0.017676
84	Number of health project at year (t-1)	0.015386
85	Number of education project at year (t-1)	0.012807
86	Number of energy project at year (t-1)	0.009538
87	Capacity building project budget at year (t-1)	0.004999
88	Governance project budget at year (t-2)	0.001633
89	Number of health project at year (t)	0.001627

APPENDIX G: SENSITIVITY ANALYSIS GRAPHS FOR THE TOP TWO RANKED VALUES

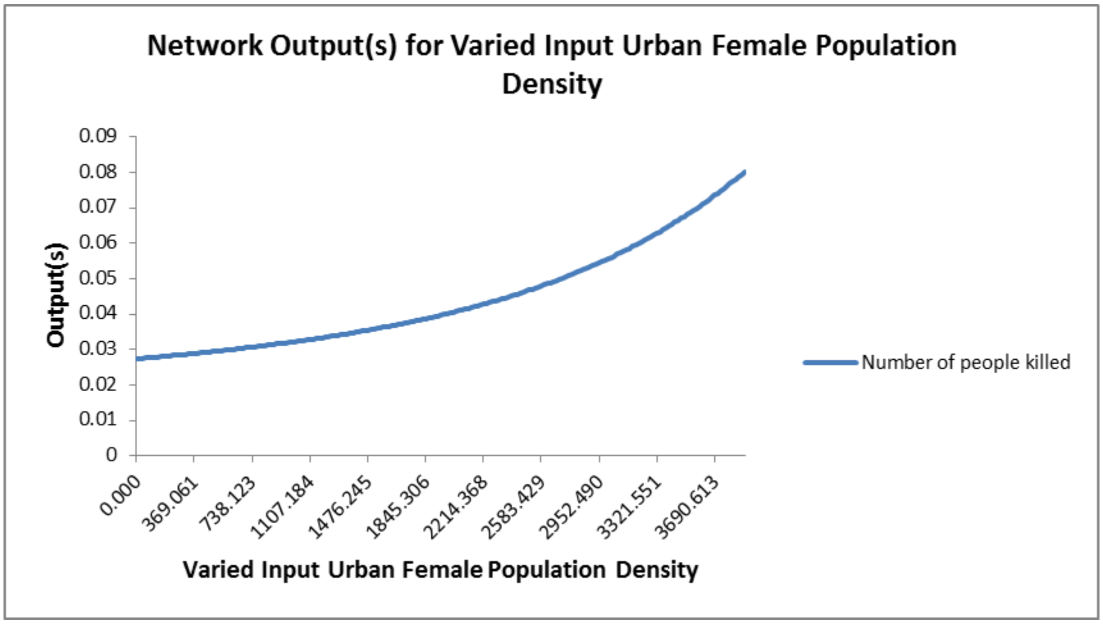


Figure 126: The effect of the first ranked independent variable on number of people killed in Central region

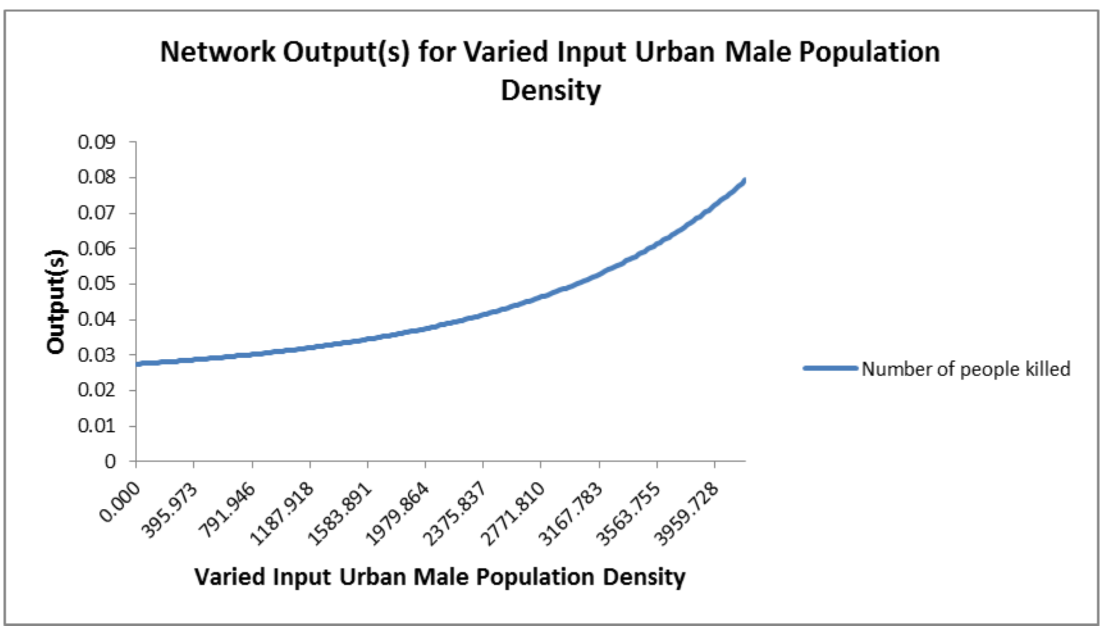


Figure 127: The effect of the second ranked independent variable on number of people killed in Central region

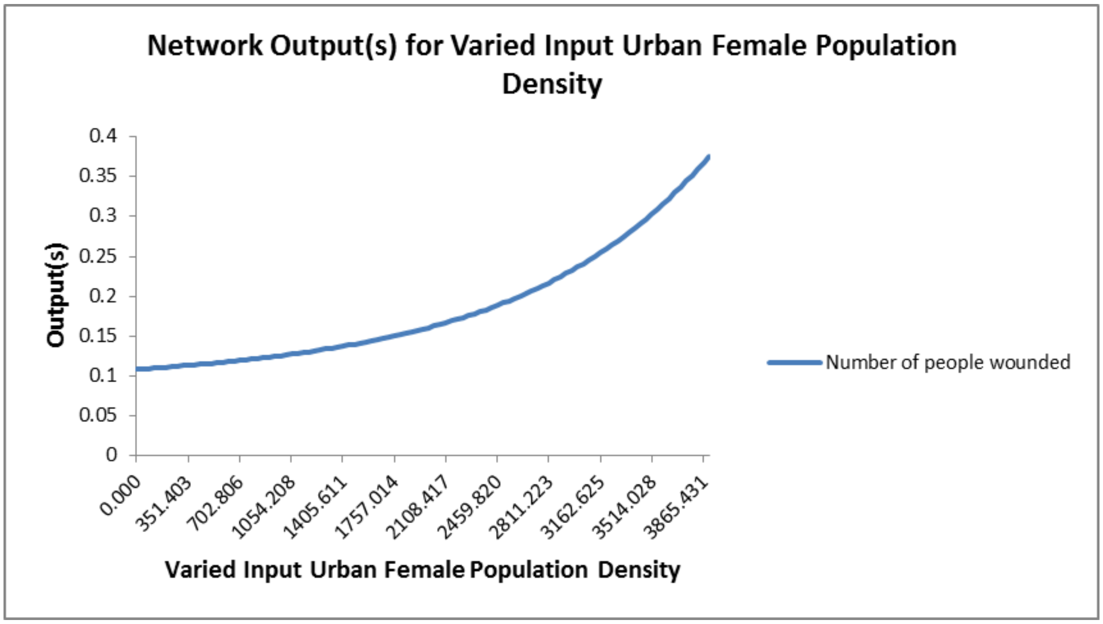


Figure 128: The effect of the first ranked independent variable on number of people wounded in Central region

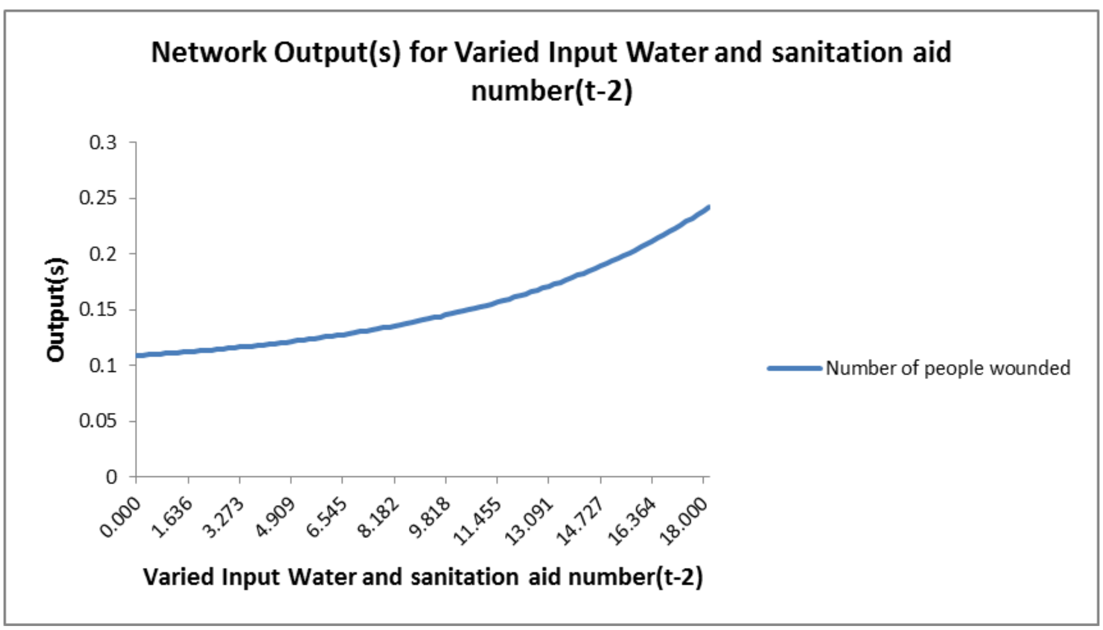


Figure 129: The effect of the second ranked independent variable on number of people wounded in Central region

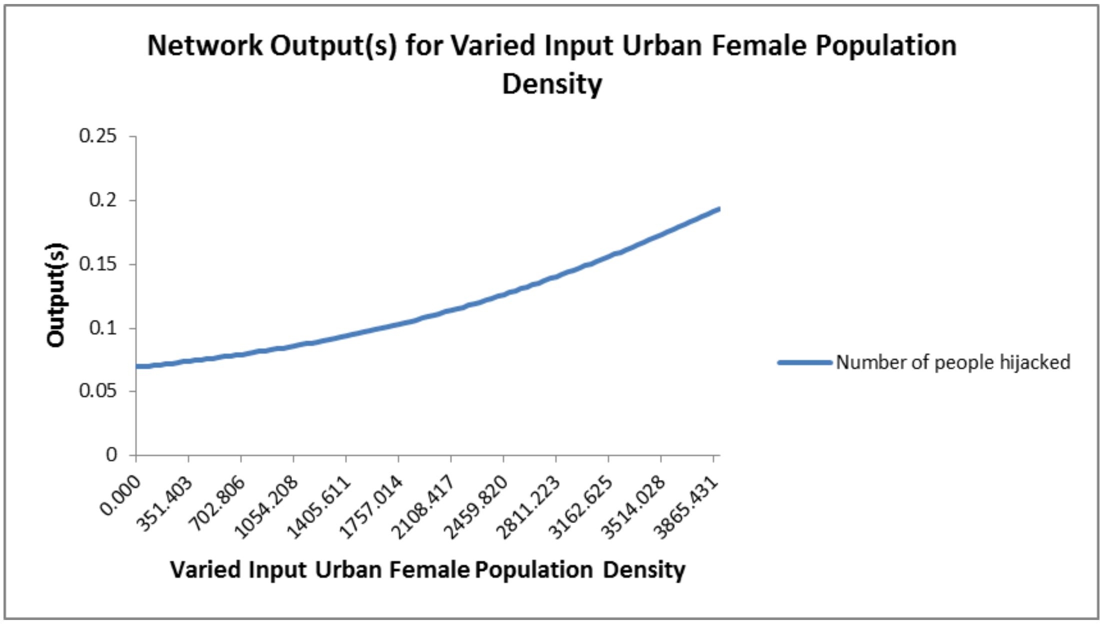


Figure 130: The effect of the first ranked independent variable on number of people hijacked in Central region

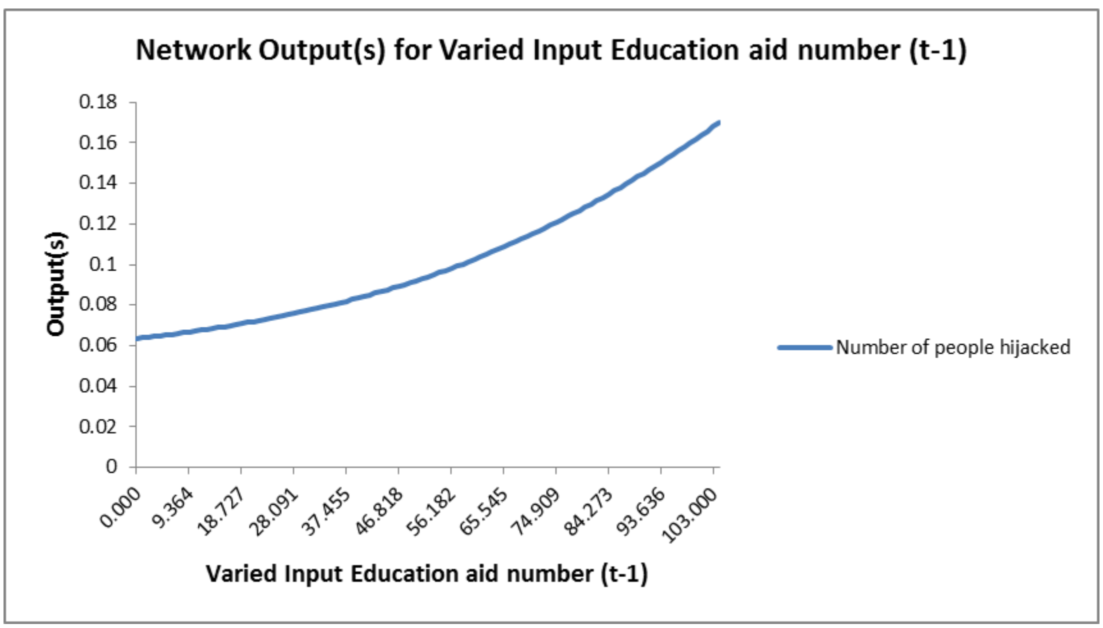


Figure 131: The effect of the second ranked independent variable on number of people hijacked in Central region

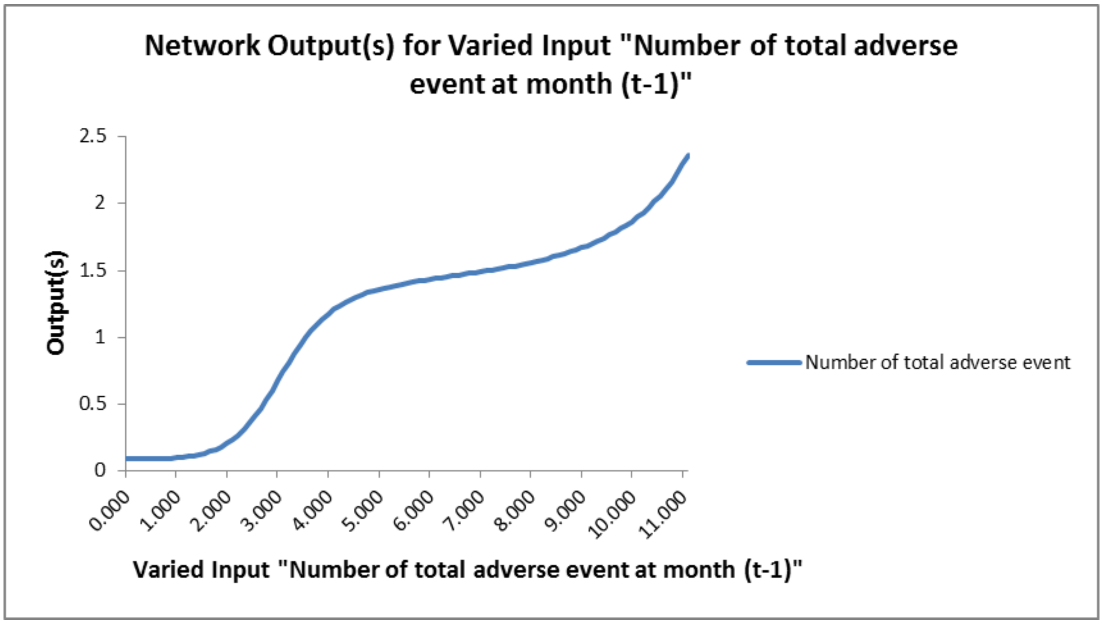


Figure 132: The effect of the first ranked independent variable on total number of adverse events in Central region

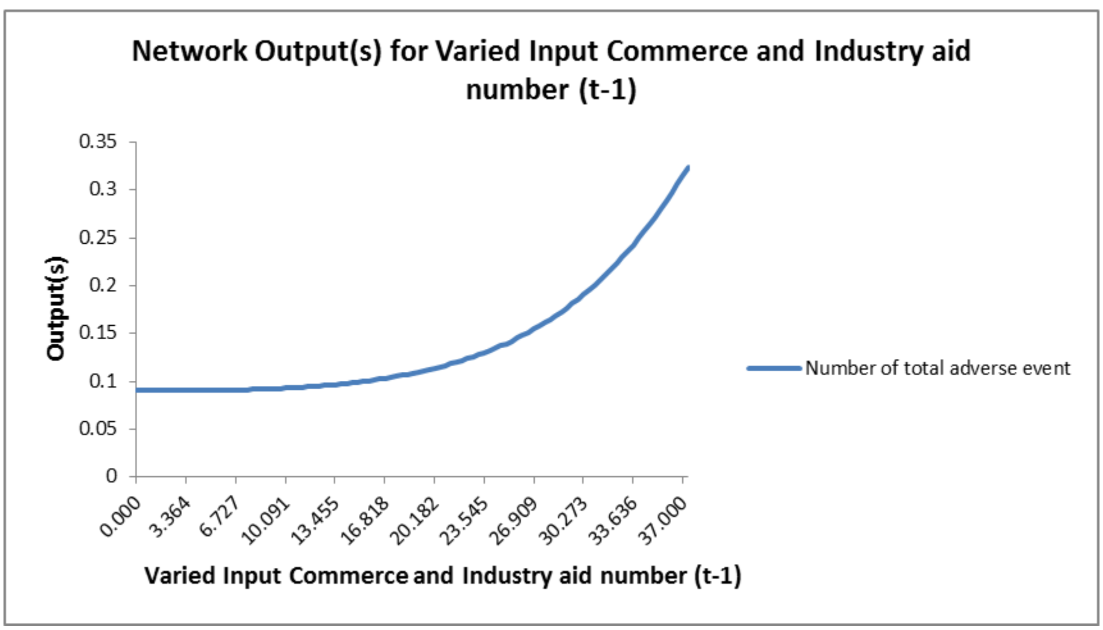


Figure 133: The effect of the second ranked independent variable on total number of adverse events in Central region

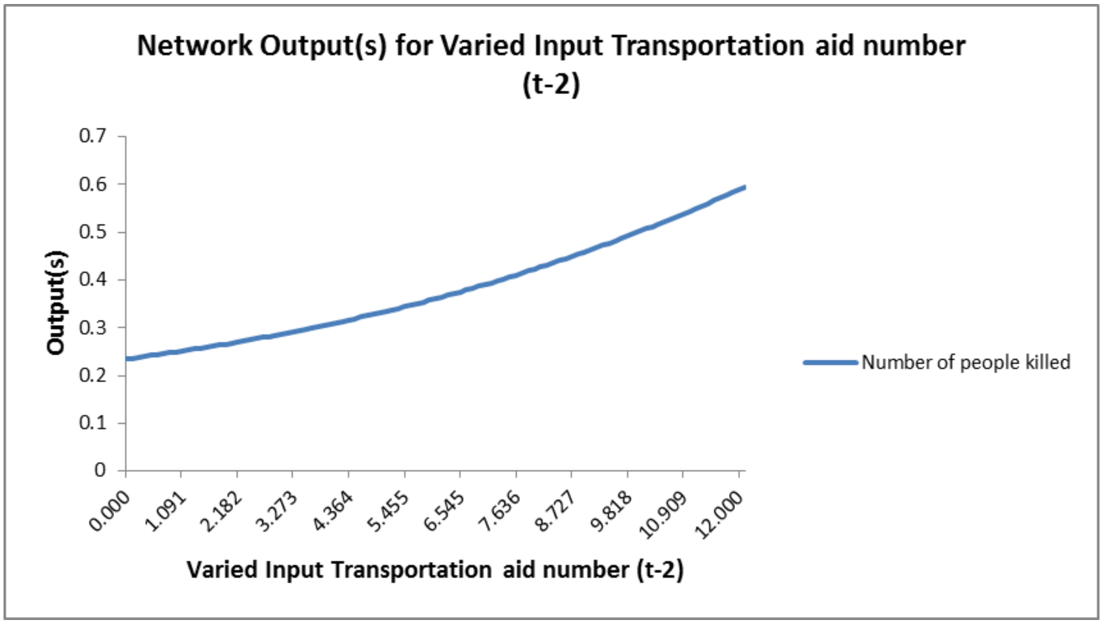


Figure 134: The effect of the first ranked independent variable on number of people killed in Eastern region

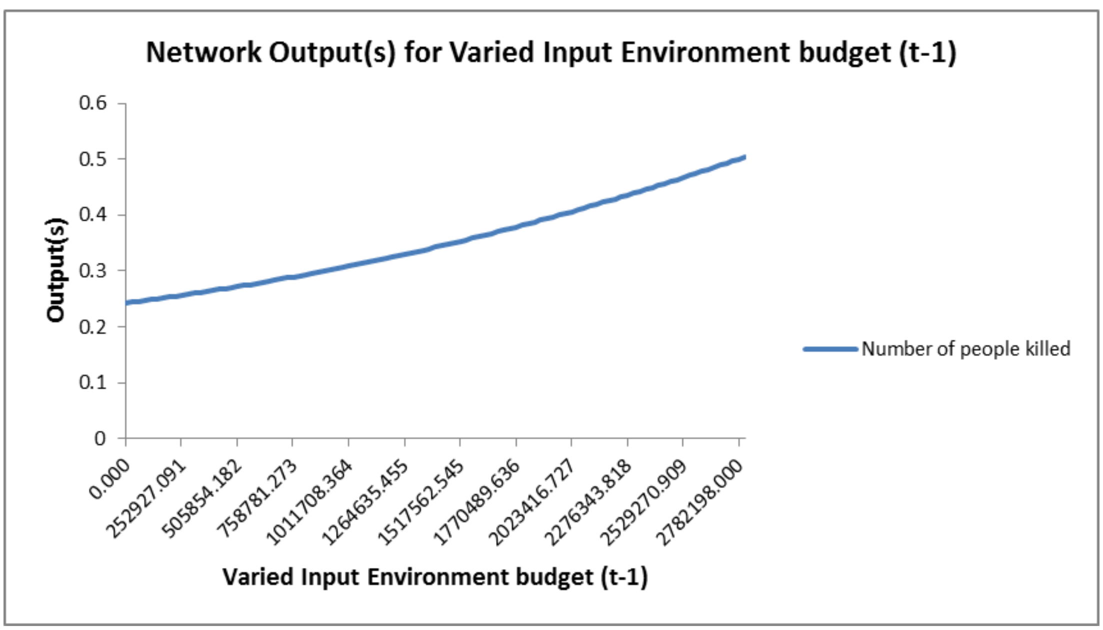


Figure 135: The effect of the second ranked independent variable on number of people killed in Eastern region

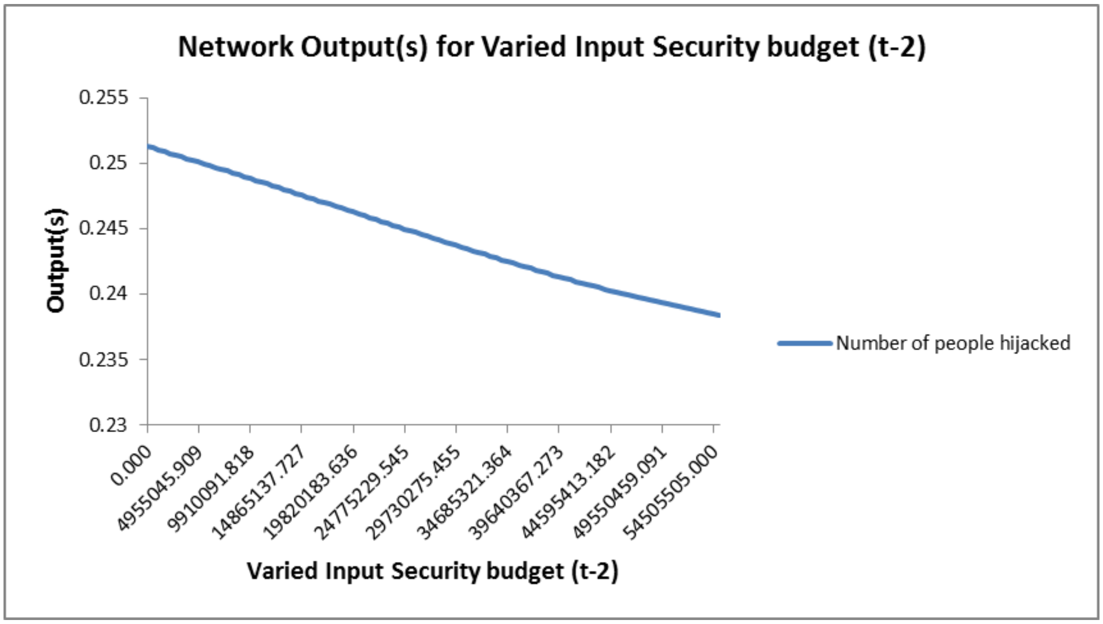


Figure 136: The effect of the first ranked independent variable on number of people hijacked in Eastern region

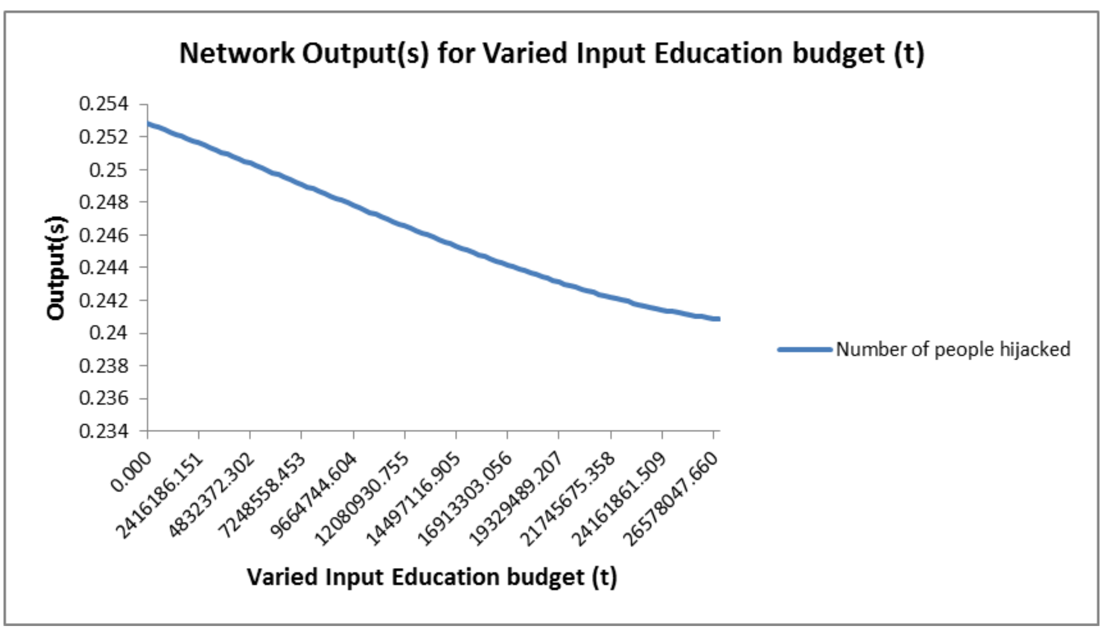


Figure 137: The effect of the second ranked independent variable on number of people hijacked in Eastern region

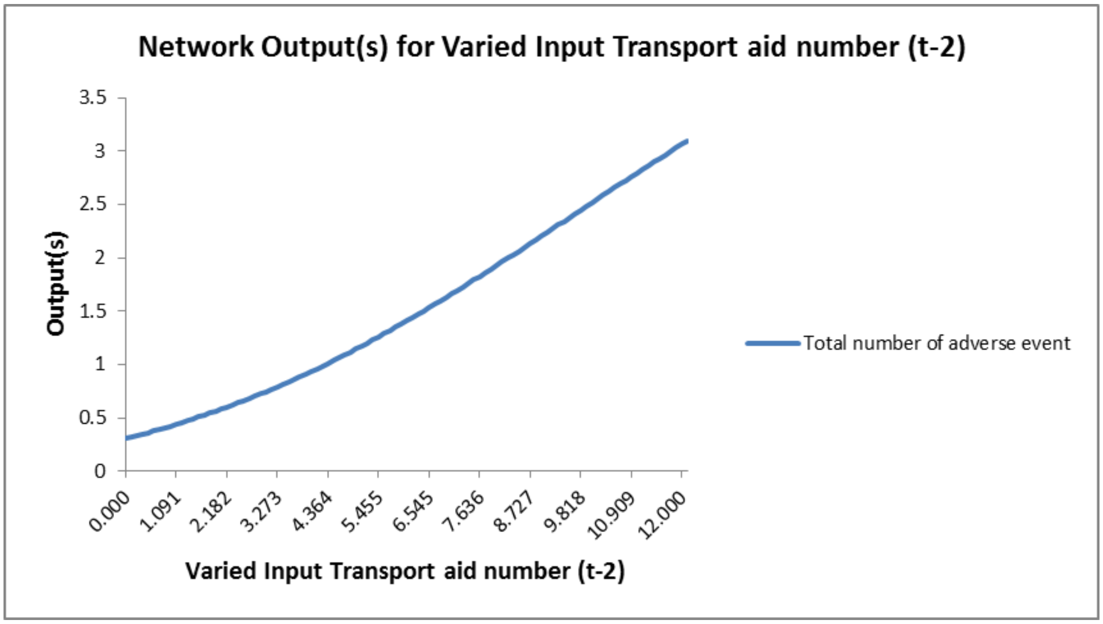


Figure 138: The effect of the first ranked independent variable on total number of adverse events in Eastern region

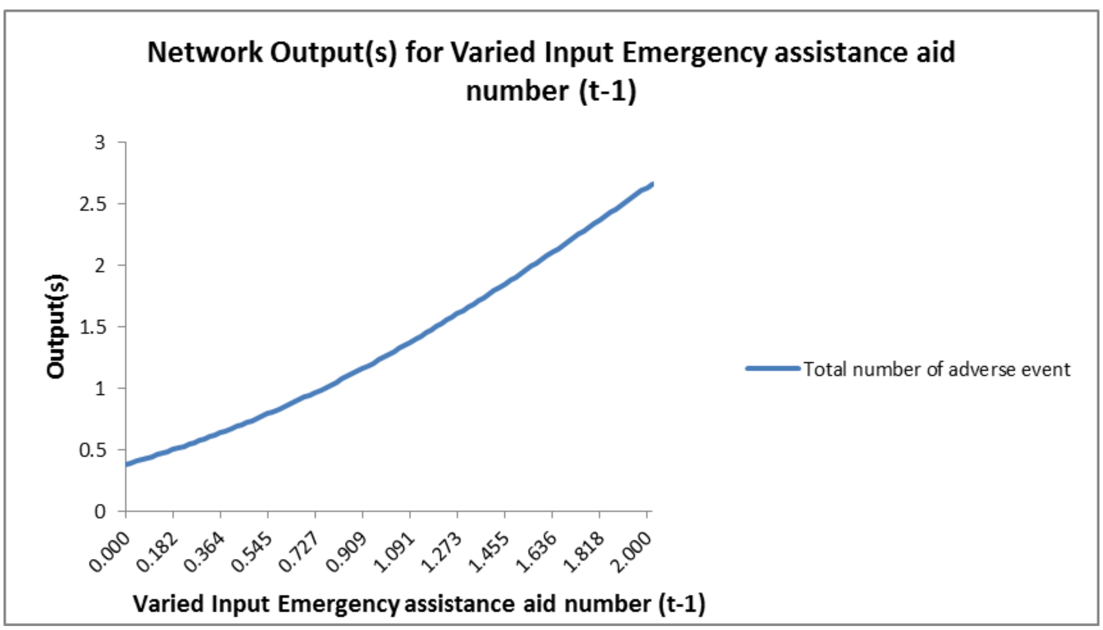


Figure 139: The effect of the second ranked independent variable on total number of adverse events in Eastern region

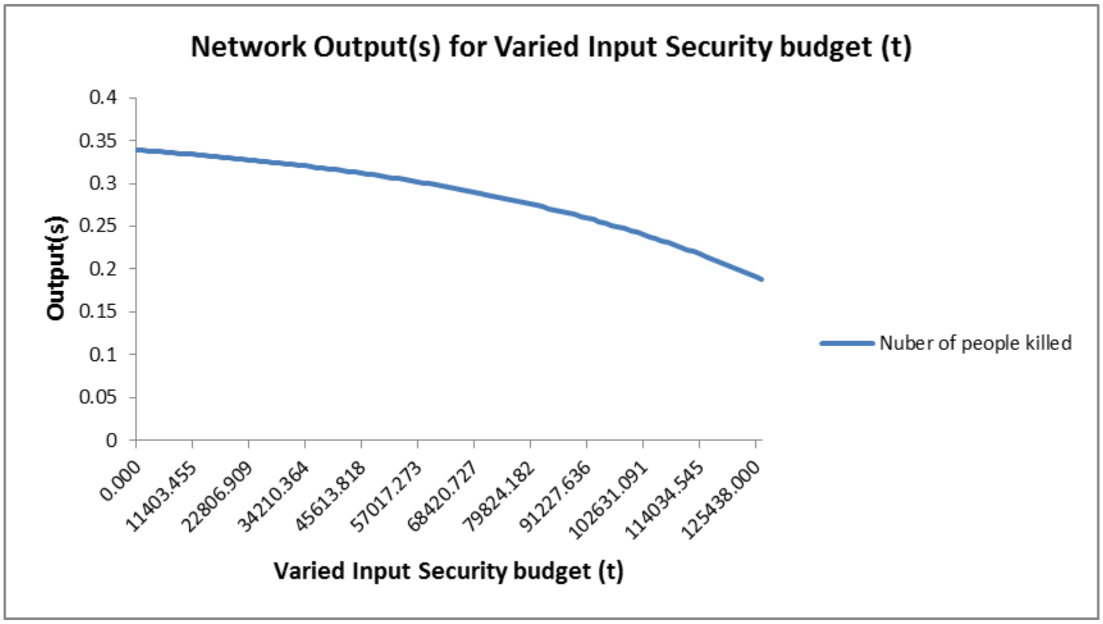


Figure 140: The effect of the first ranked independent variable on number of people killed in North Eastern region

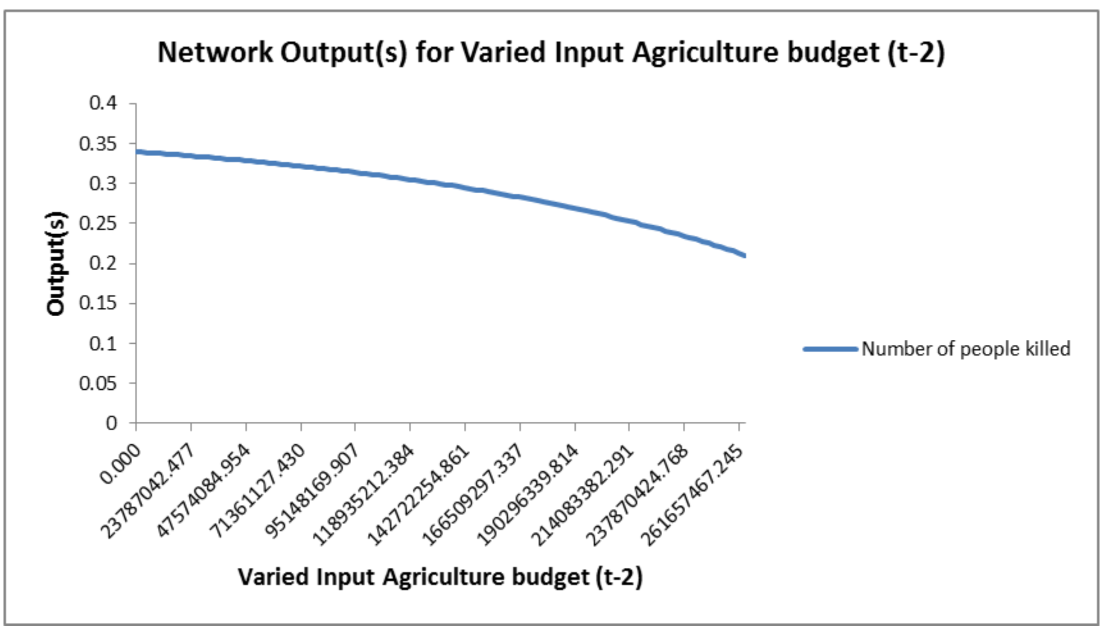


Figure 141: The effect of the second ranked independent variable on number of people killed in North Eastern region

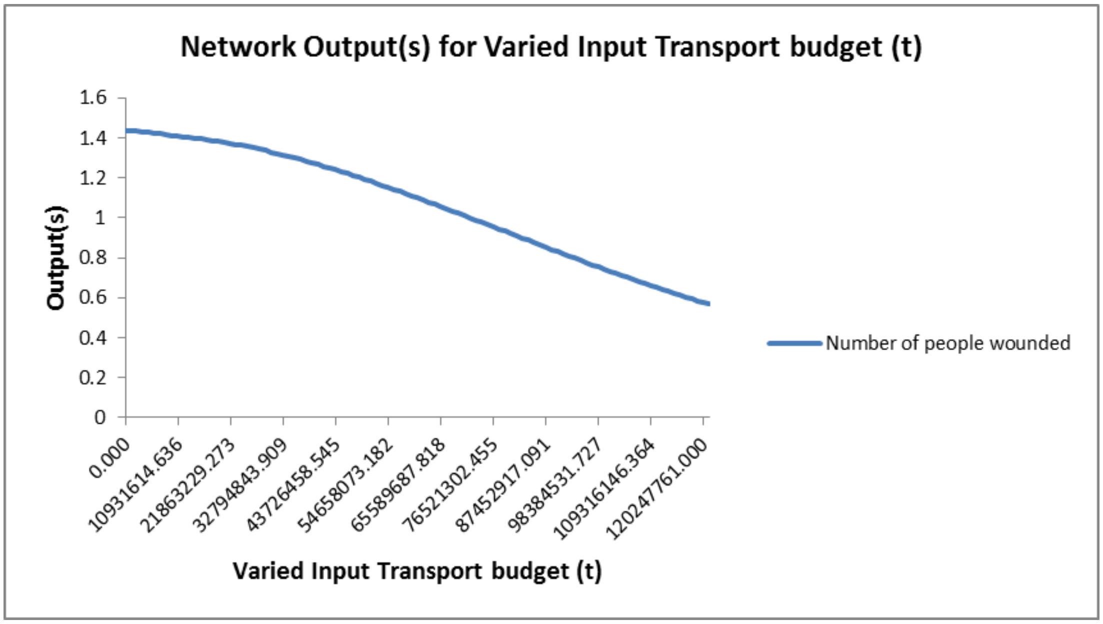


Figure 142: The effect of the first ranked independent variable on number of people wounded in North Eastern region

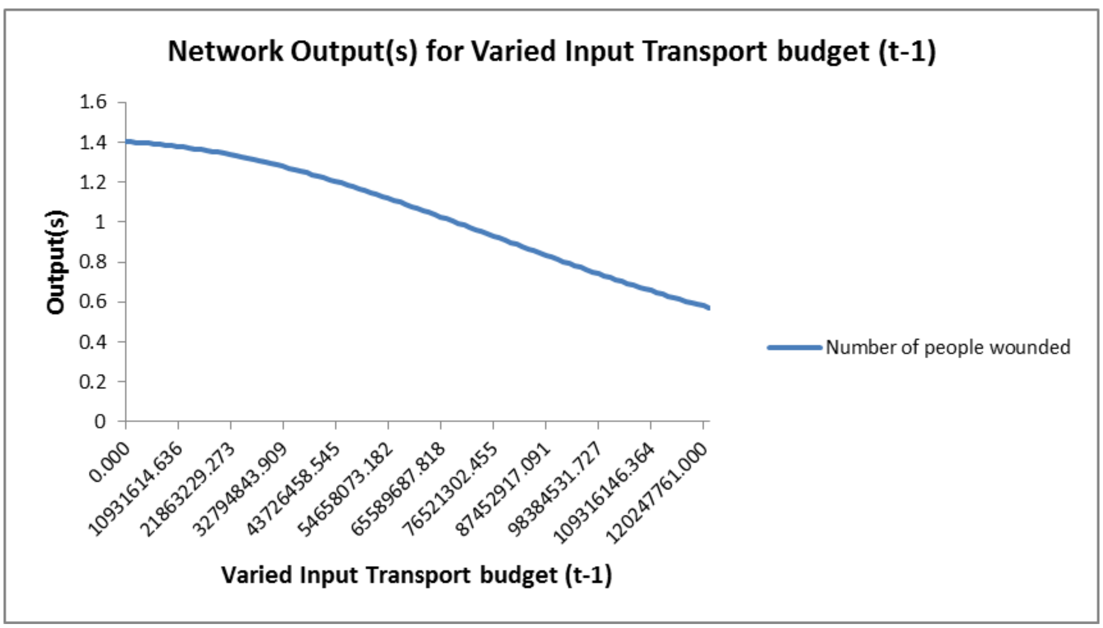


Figure 143: The effect of the second ranked independent variable on number of people wounded in North Eastern region

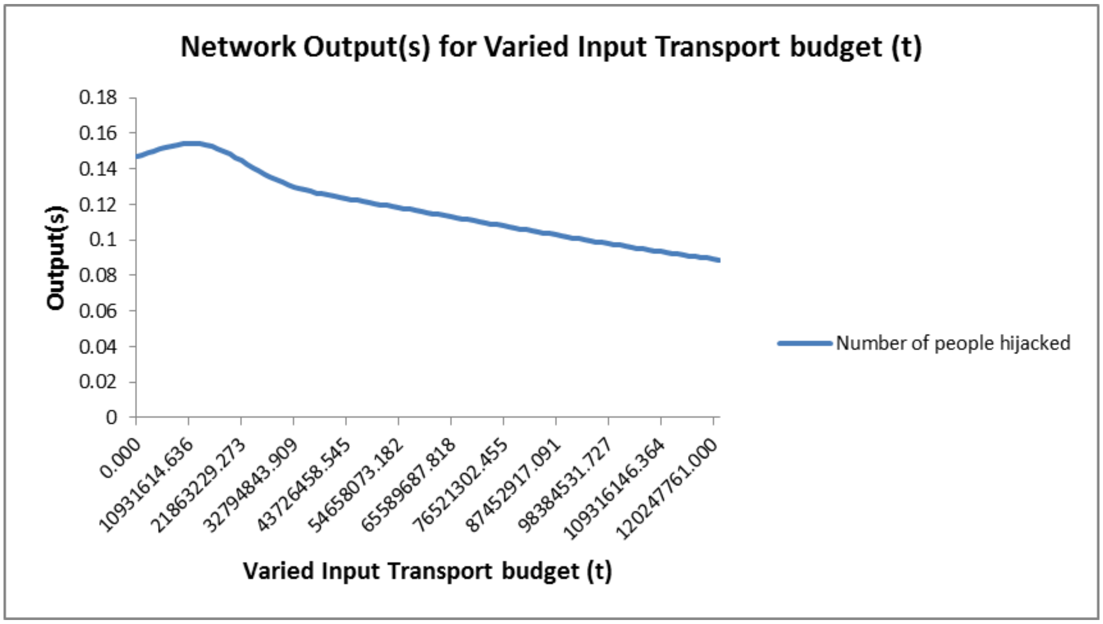


Figure 144: The effect of the first ranked independent variable on number of people hijacked in North Eastern region

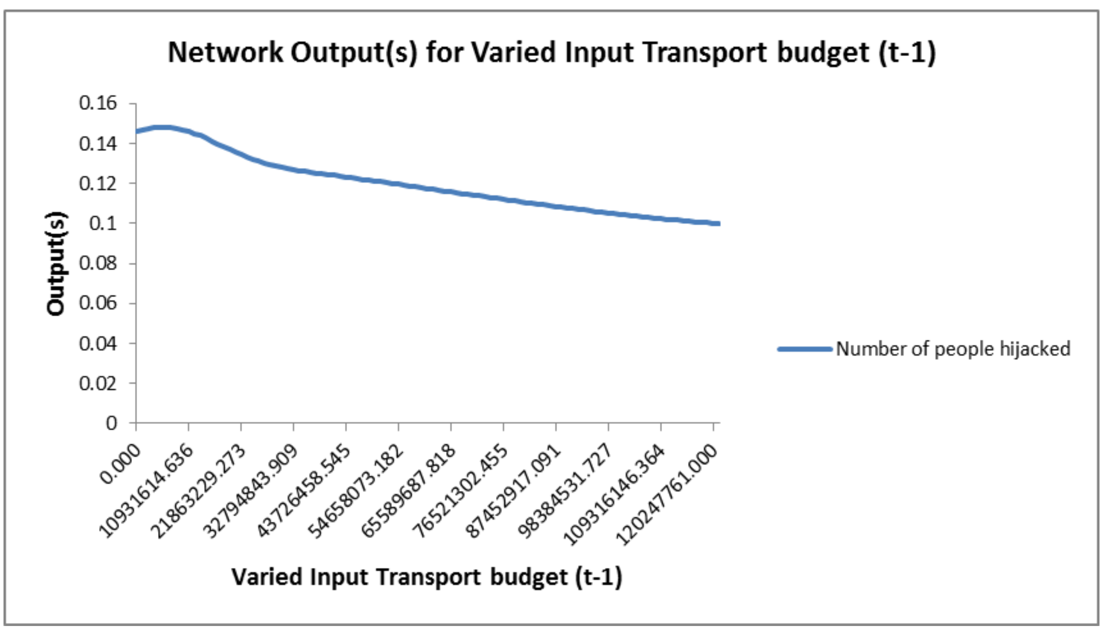


Figure 145: The effect of the second ranked independent variable on number of people hijacked in North Eastern region

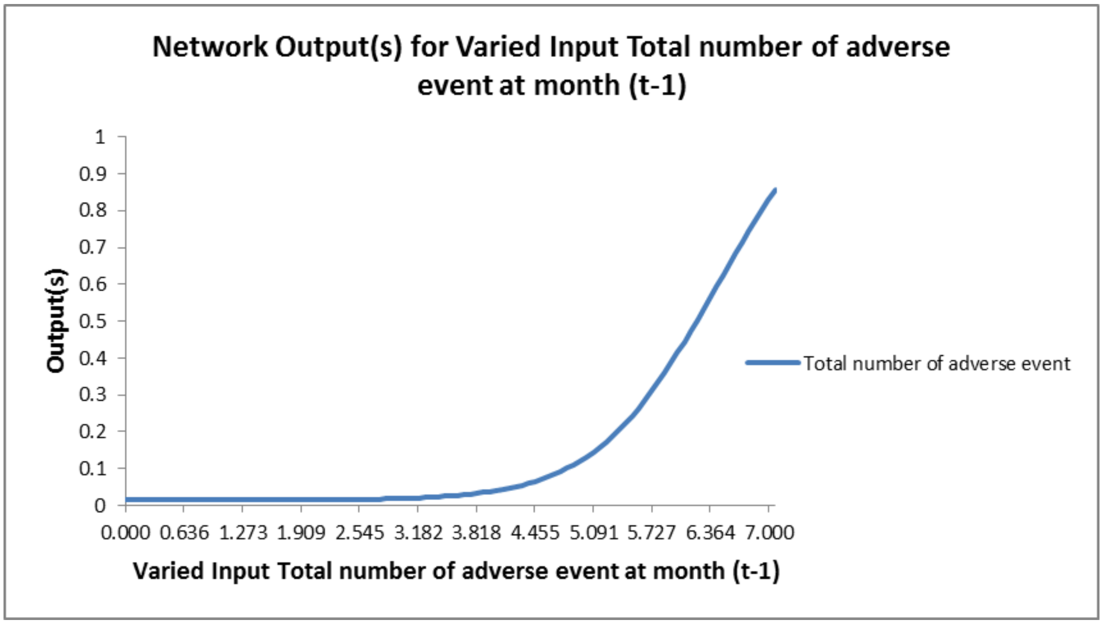


Figure 146: The effect of the first ranked independent variable on total number of adverse events in North Eastern region

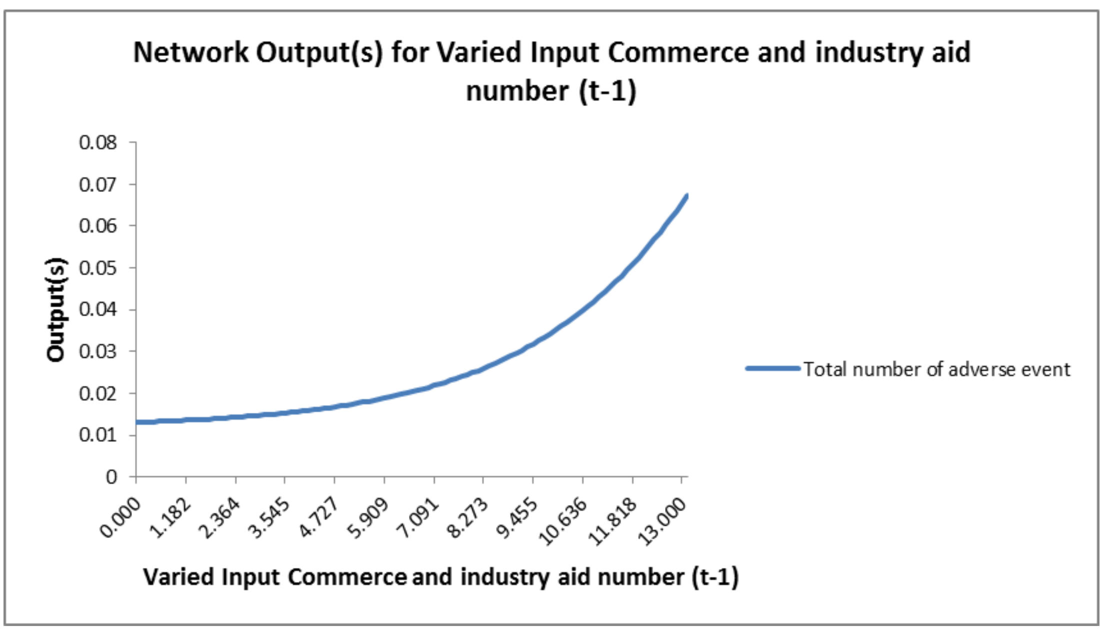


Figure 147: The effect of the second ranked independent variable on total number of adverse events in North Eastern region

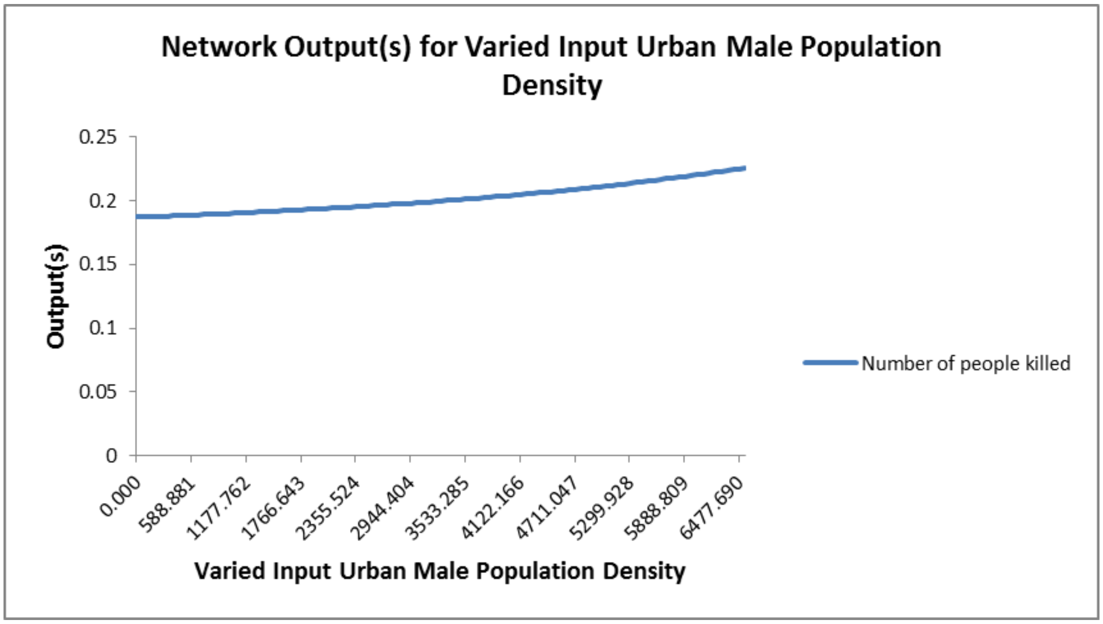


Figure 148: The effect of the first ranked independent variable on number of people killed in North Western region

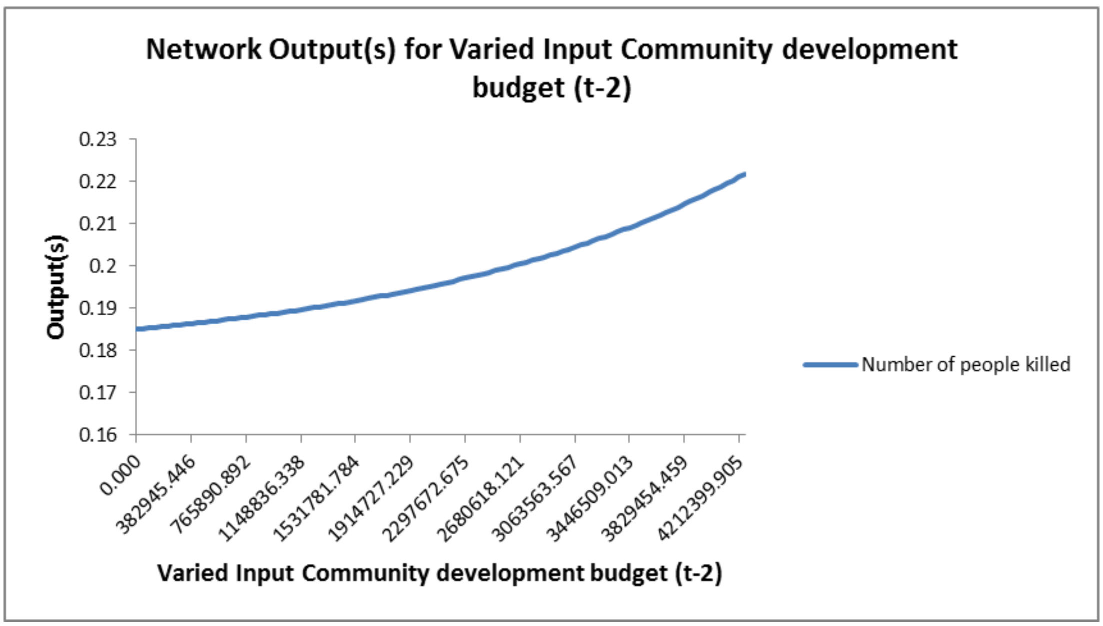


Figure 149: The effect of the second ranked independent variable on number of people killed in North Western region

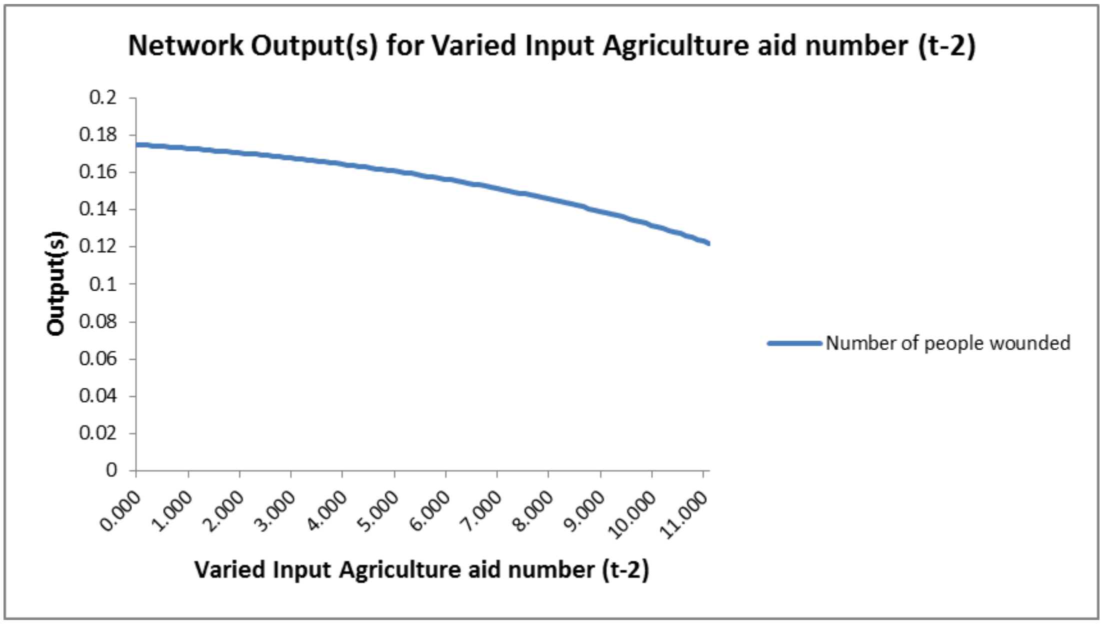


Figure 150: The effect of the first ranked independent variable on number of people wounded in North Western region

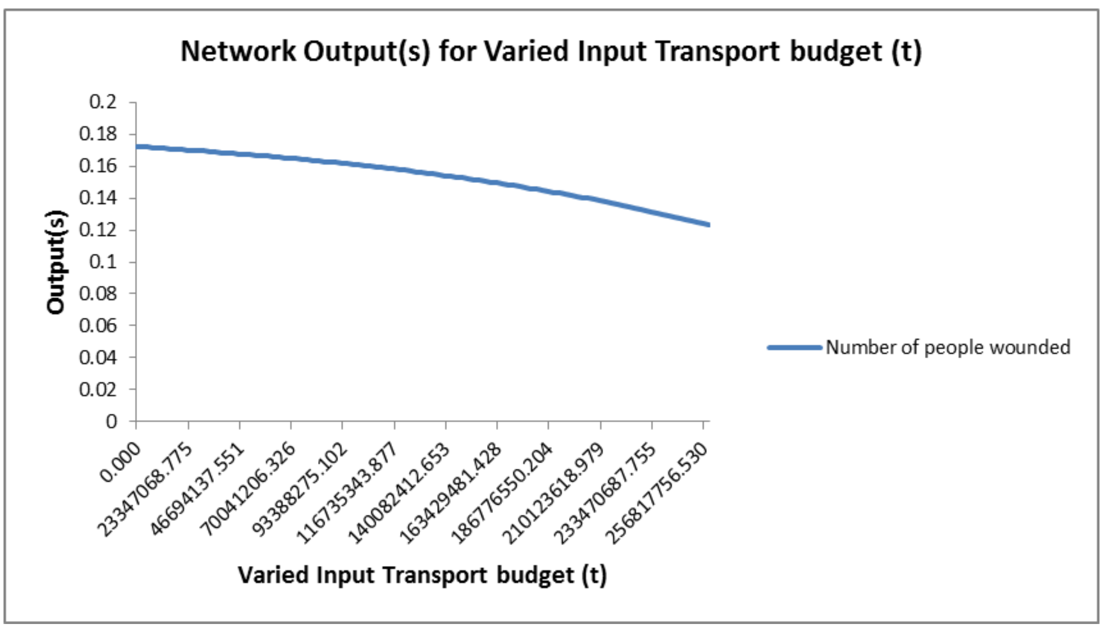


Figure 151: The effect of the second ranked independent variable on number of people wounded in North Western region

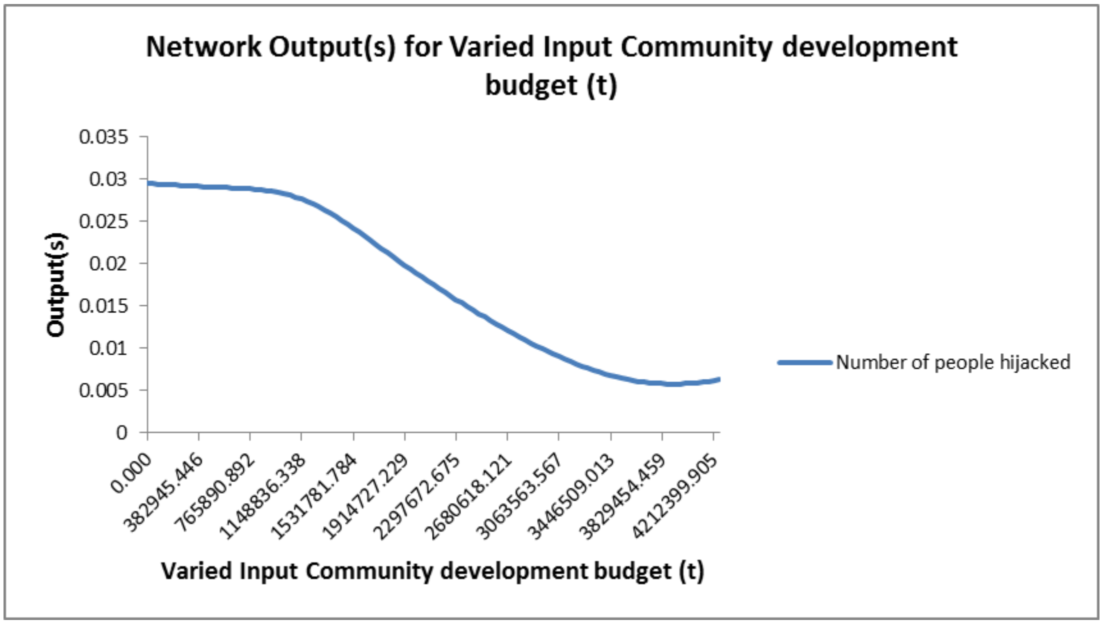


Figure 152: The effect of the first ranked independent variable on number of people hijacked in North Western region

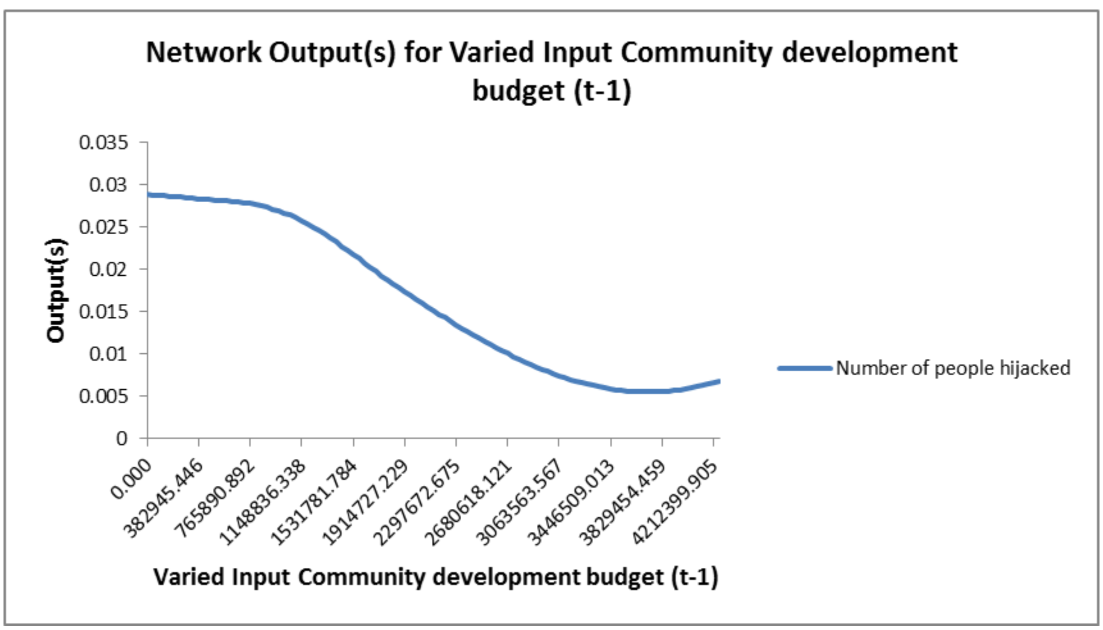


Figure 153: The effect of the second ranked independent variable on number of people hijacked in North Western region

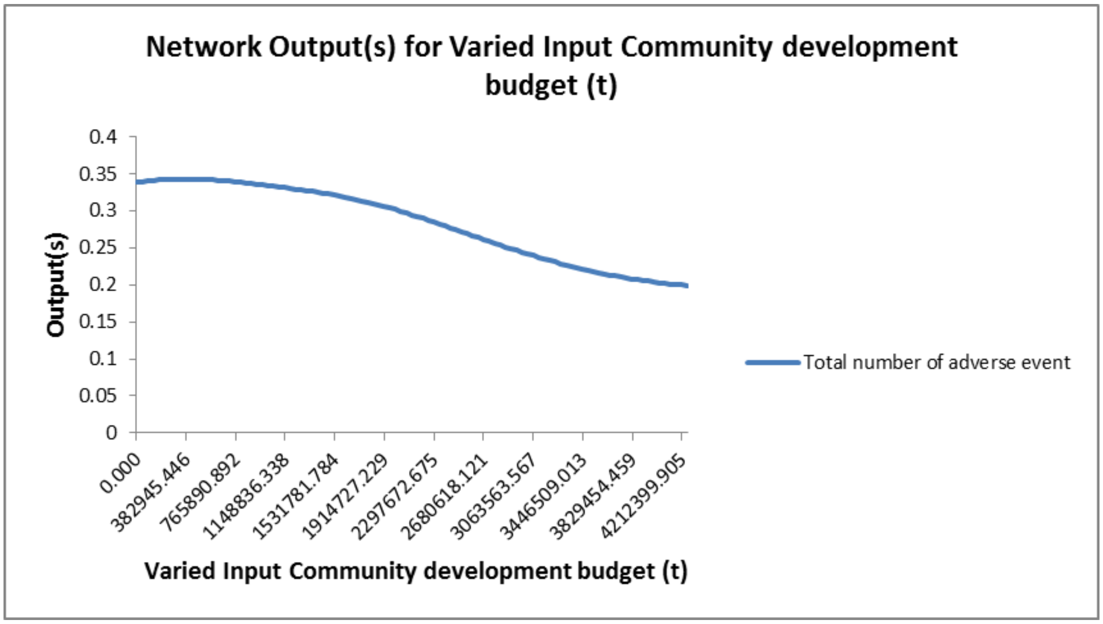


Figure 154: The effect of the first ranked independent variable on total number of adverse events in North Western region

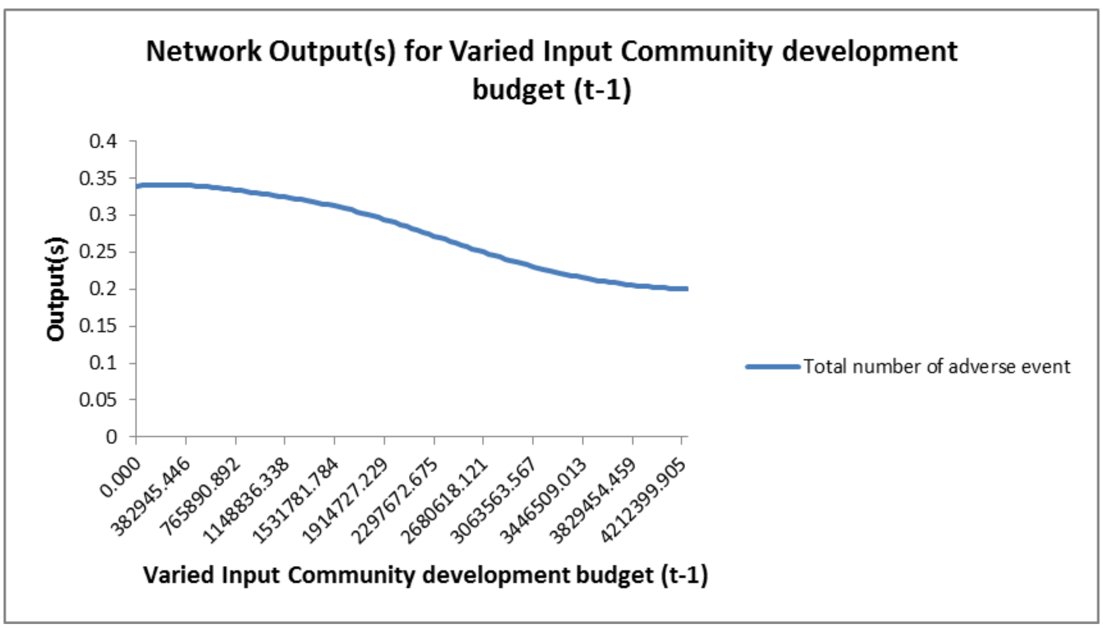


Figure 155: The effect of the second ranked independent variable on total number of adverse events in North Western region

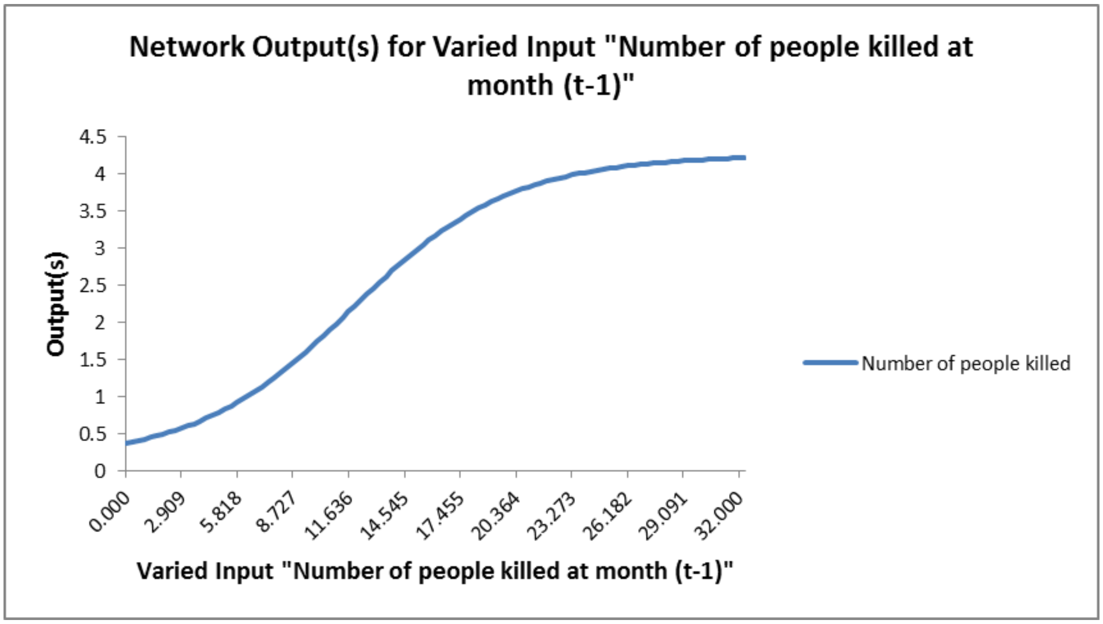


Figure 156: The effect of the first ranked independent variable on number of people killed in South Eastern region

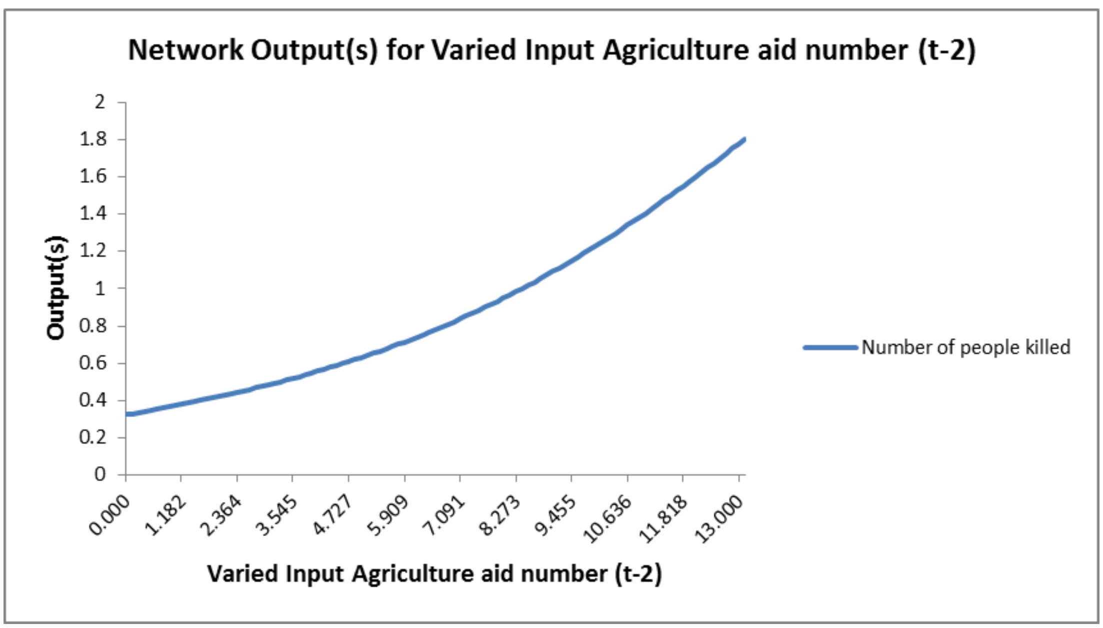


Figure 157: The effect of the second ranked independent variable on number of people killed in South Eastern region

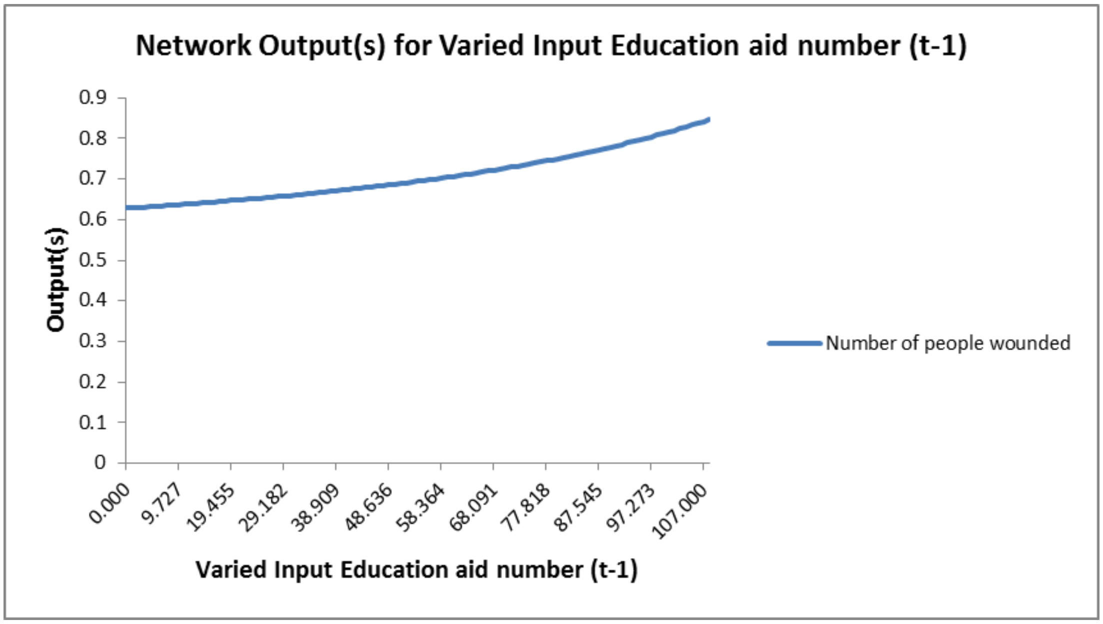


Figure 158: The effect of the first ranked independent variable on number of people wounded in South Eastern region

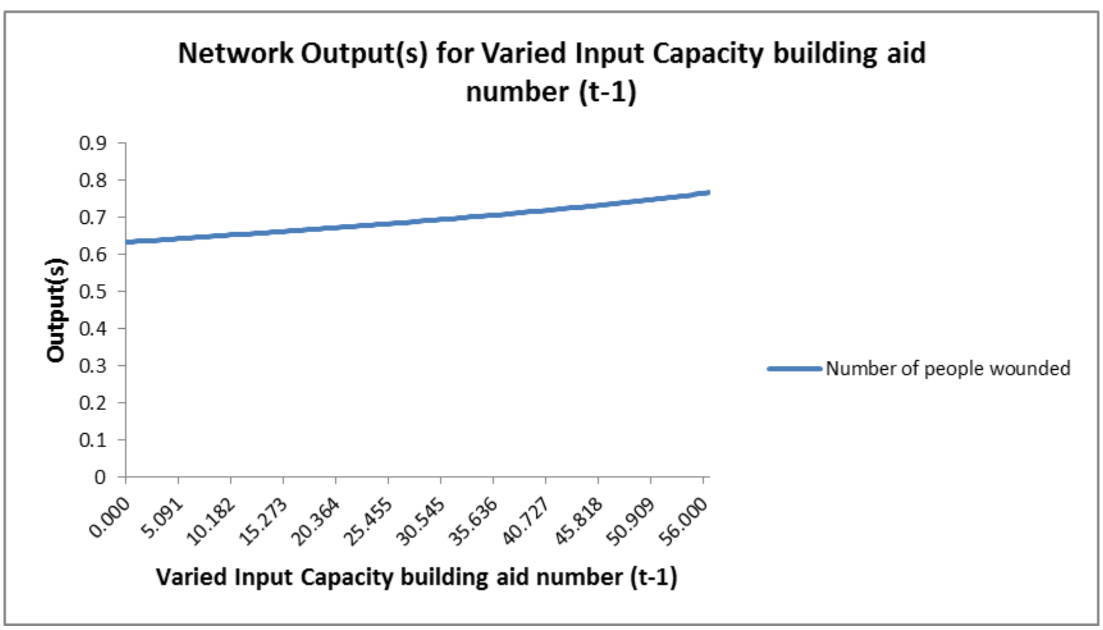


Figure 159: The effect of the second ranked independent variable on number of people wounded in South Eastern region

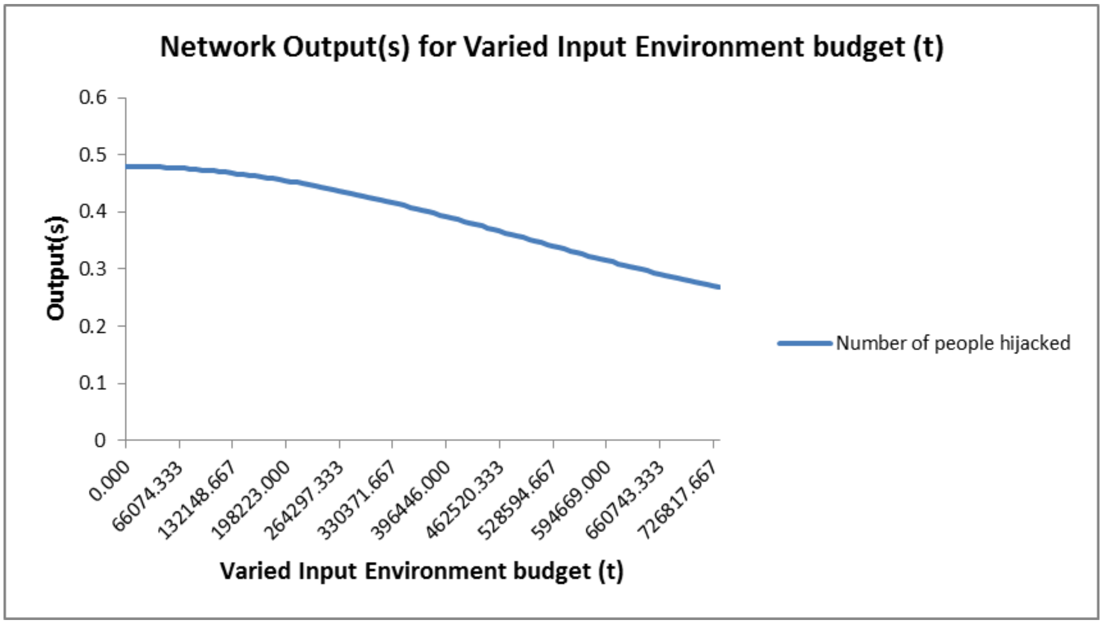


Figure 160: The effect of the first ranked independent variable on number of people hijacked in South Eastern region

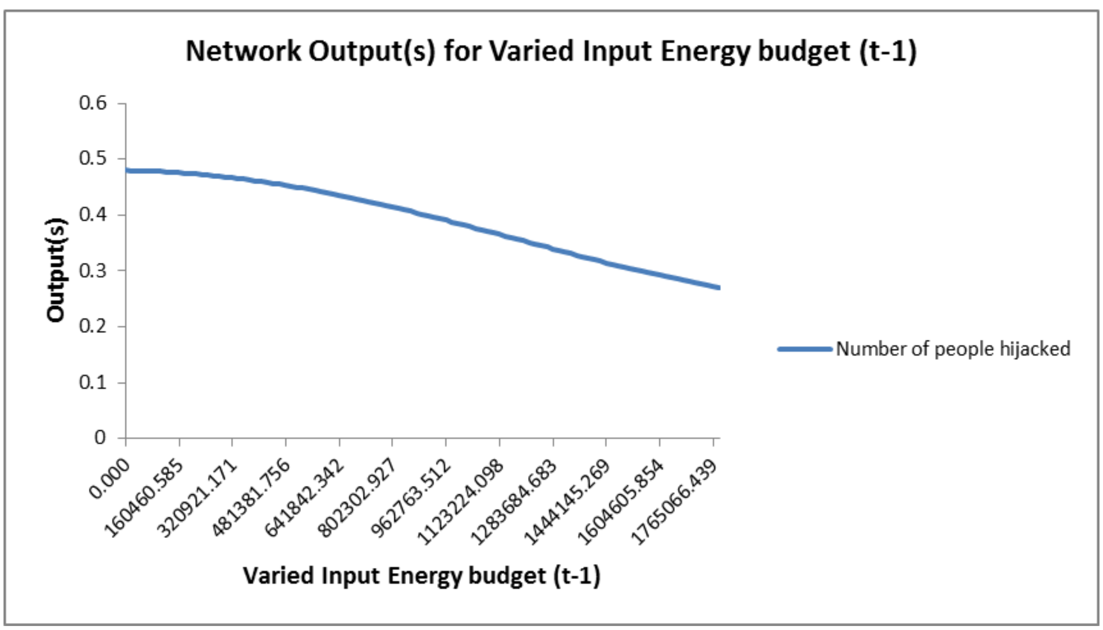


Figure 161: The effect of the second ranked independent variable on number of people hijacked in South Eastern region

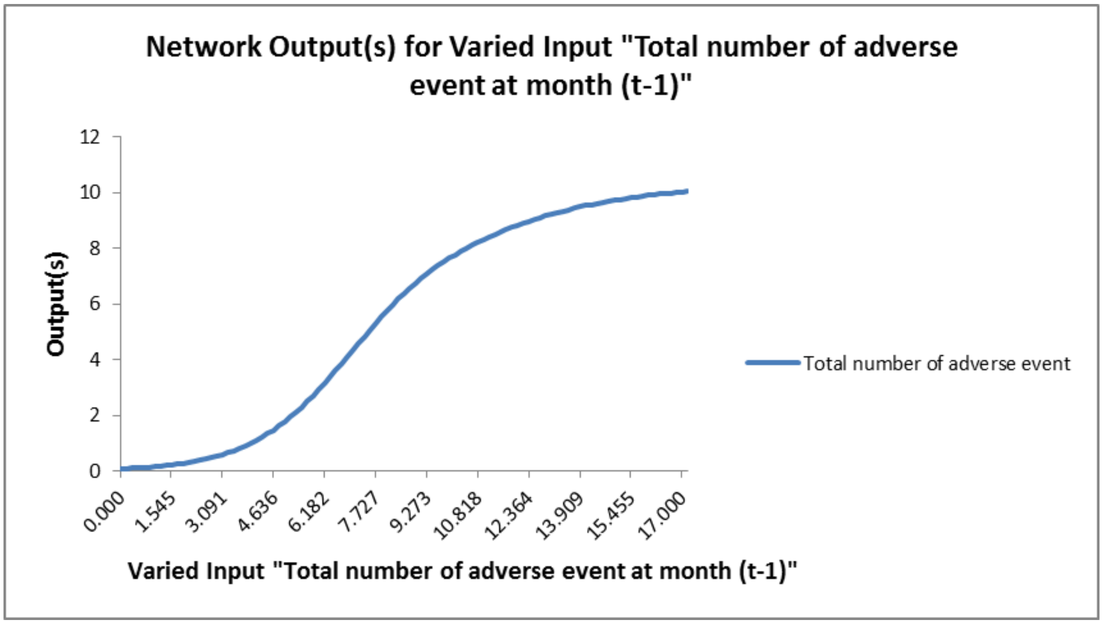


Figure 162: The effect of the first ranked independent variable on total number of adverse events in South Eastern region

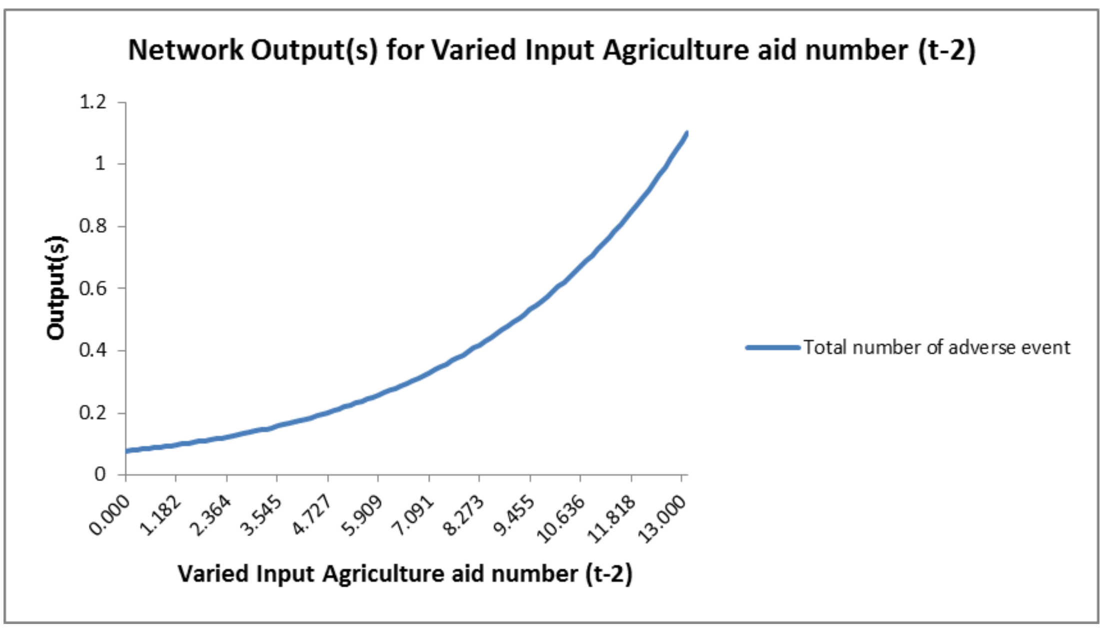


Figure 163: The effect of the second ranked independent variable on total number of adverse events in South Eastern region

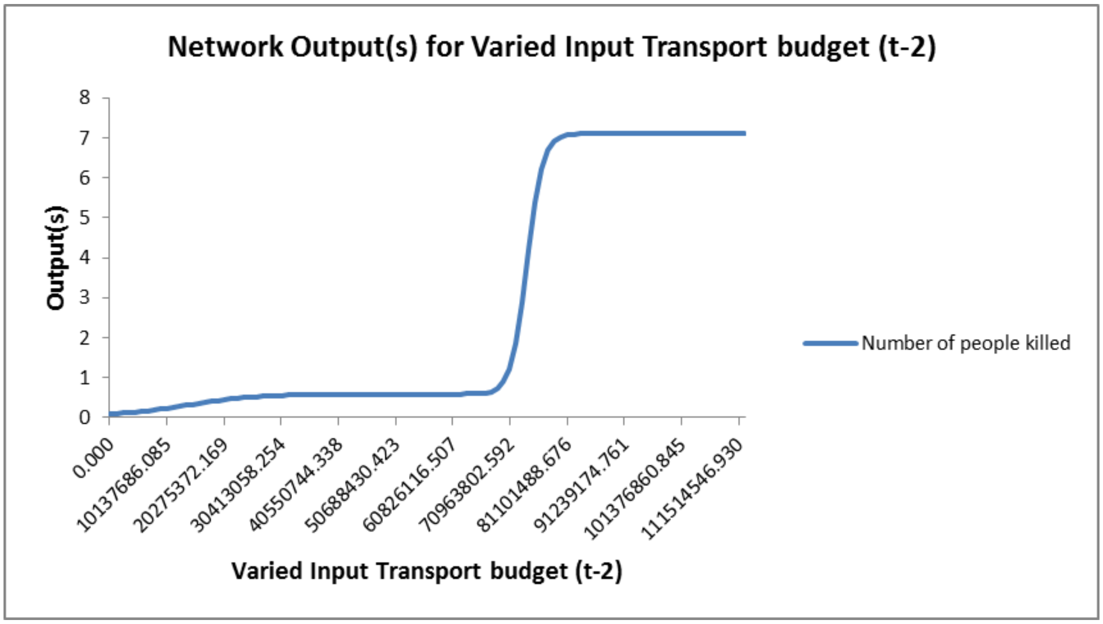


Figure 164: The effect of the first ranked independent variable on number of people killed in South Western region

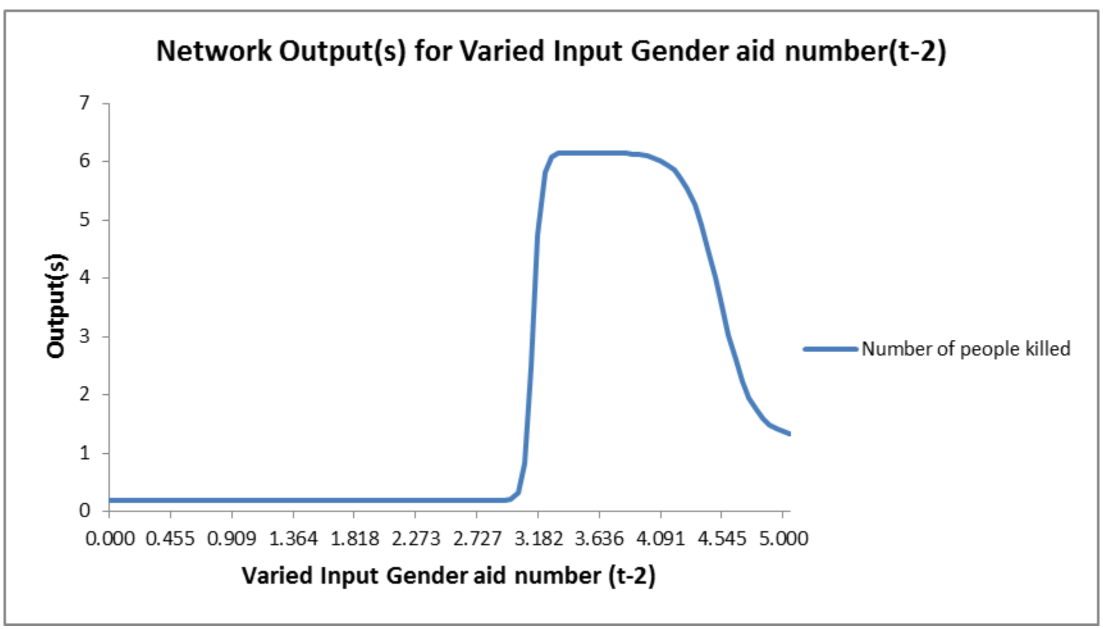


Figure 165: The effect of the second ranked independent variable on number of people killed in South Western region

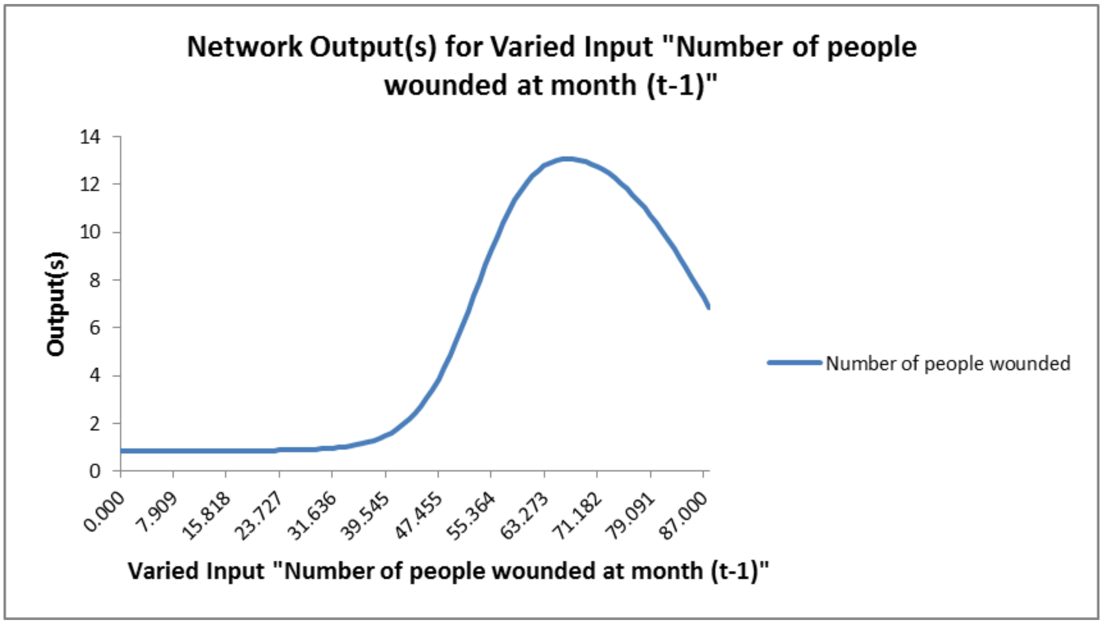


Figure 166: The effect of the first ranked independent variable on number of people wounded in South Western region

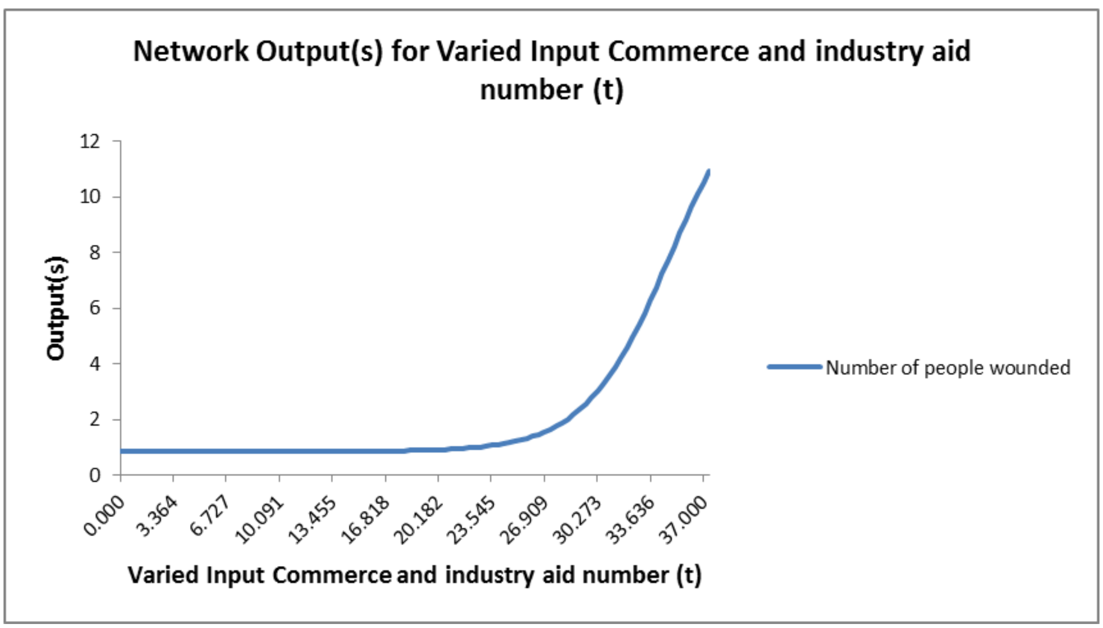


Figure 167: The effect of the second ranked independent variable on number of people wounded in South Western region

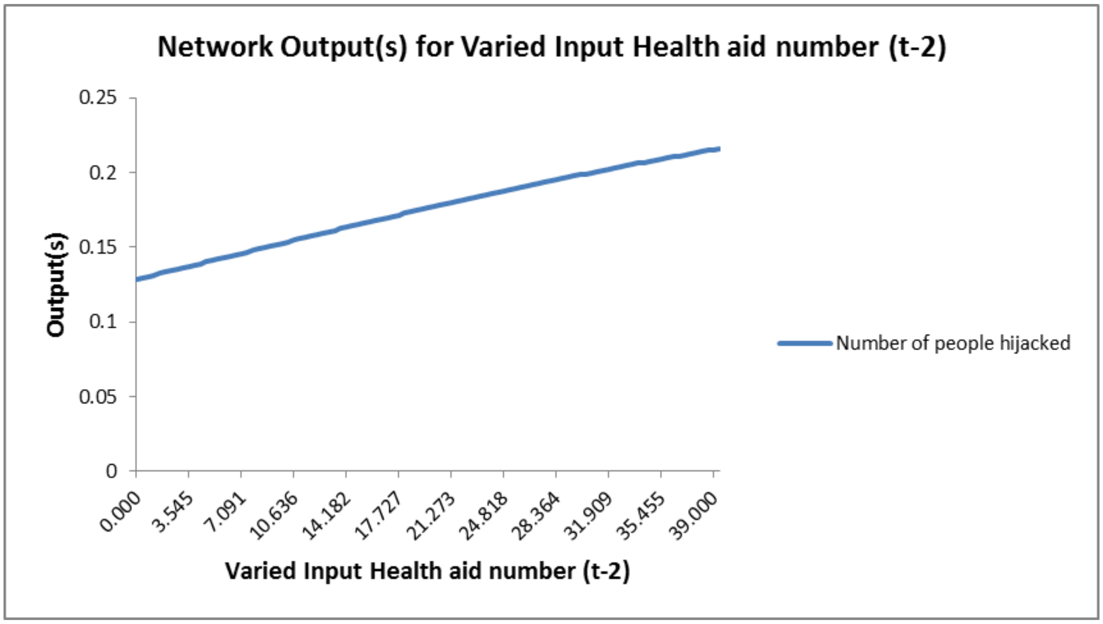


Figure 168: The effect of the first ranked independent variable on number of people hijacked in South Western region

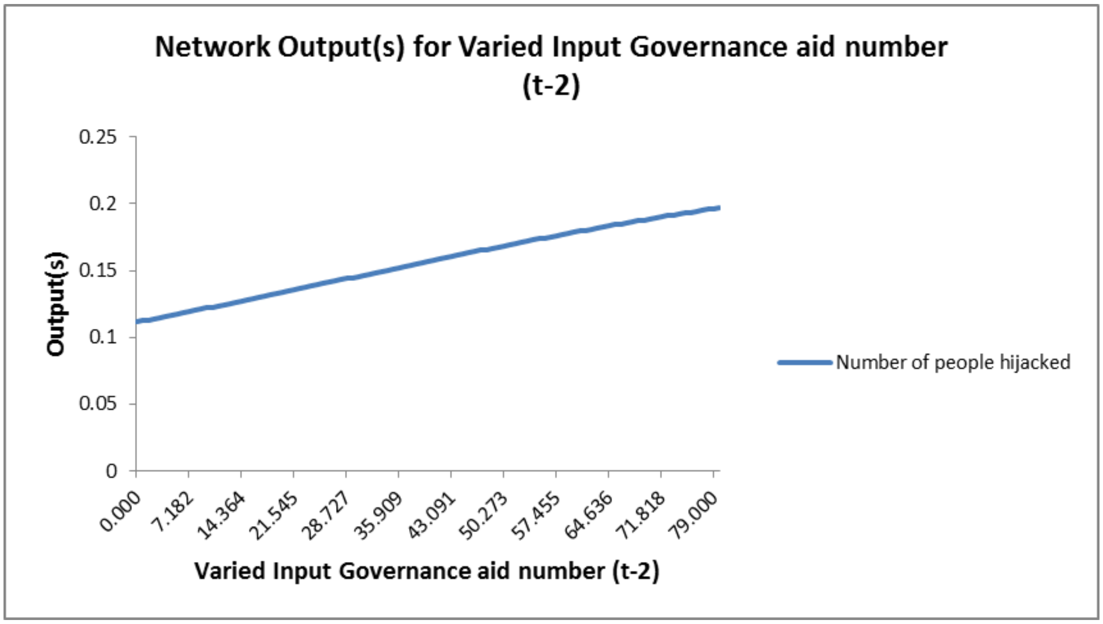


Figure 169: The effect of the second ranked independent variable on number of people hijacked in South Western region

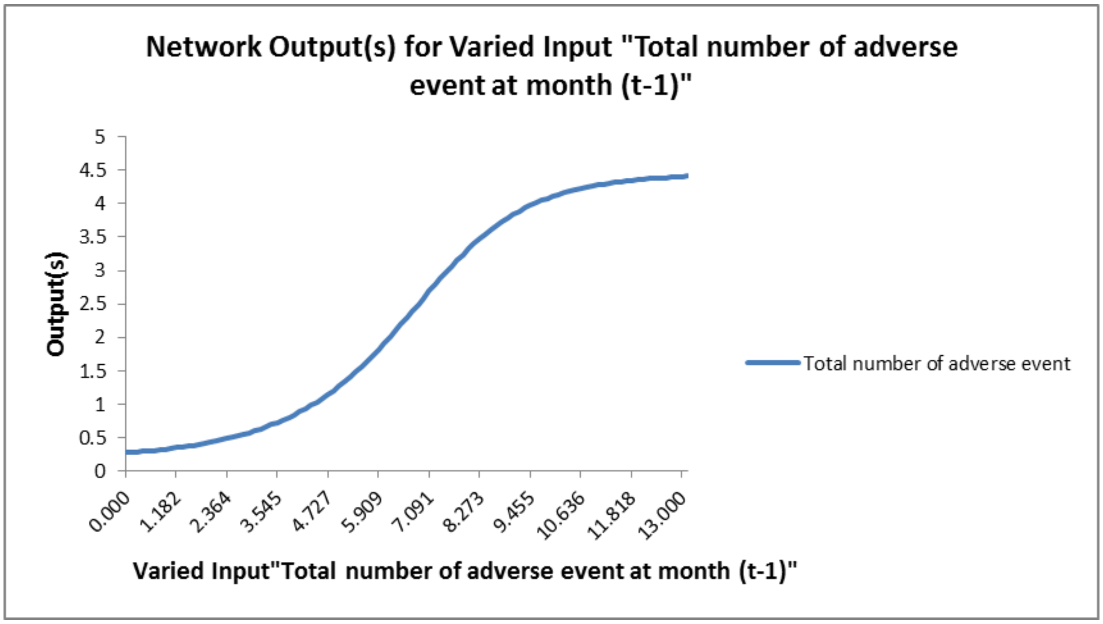


Figure 170: The effect of the first ranked independent variable on total number of adverse events in South Western region

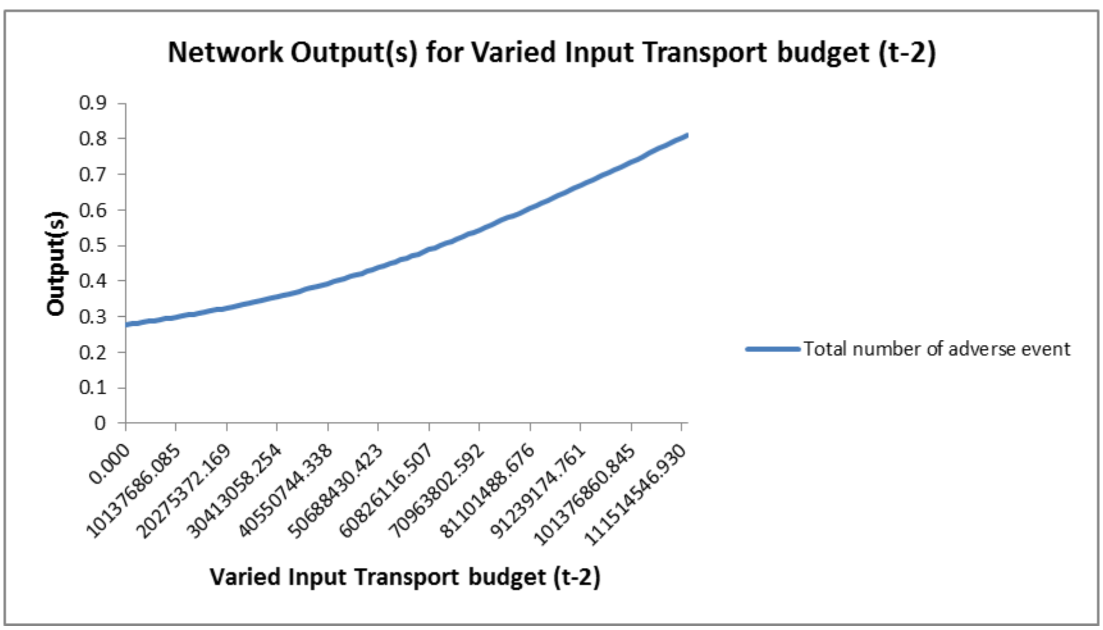


Figure 171: The effect of the second ranked independent variable on total number of adverse events in South Western region

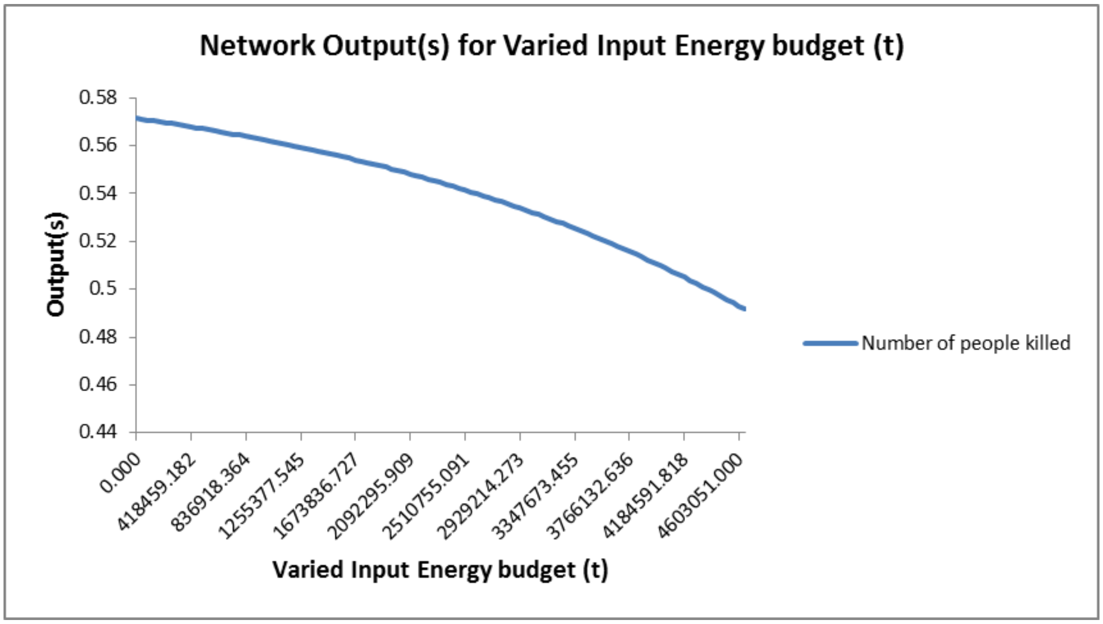


Figure 172: The effect of the first ranked independent variable on number of people killed in Western region

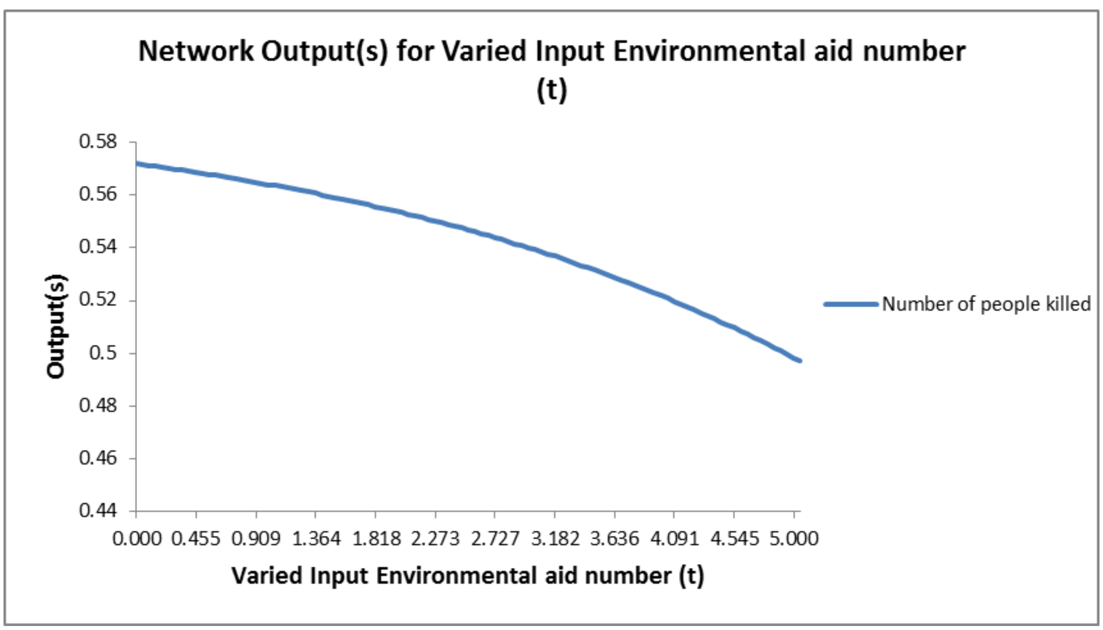


Figure 173: The effect of the second ranked independent variable on number of people killed in Western region

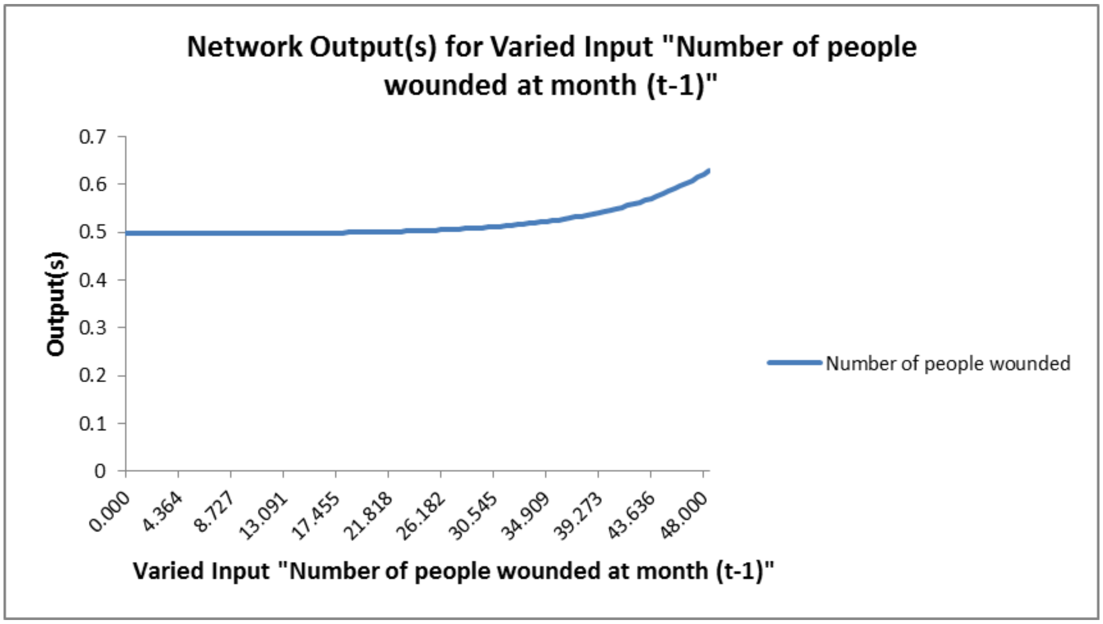


Figure 174: The effect of the first ranked independent variable on number of people wounded in Western region

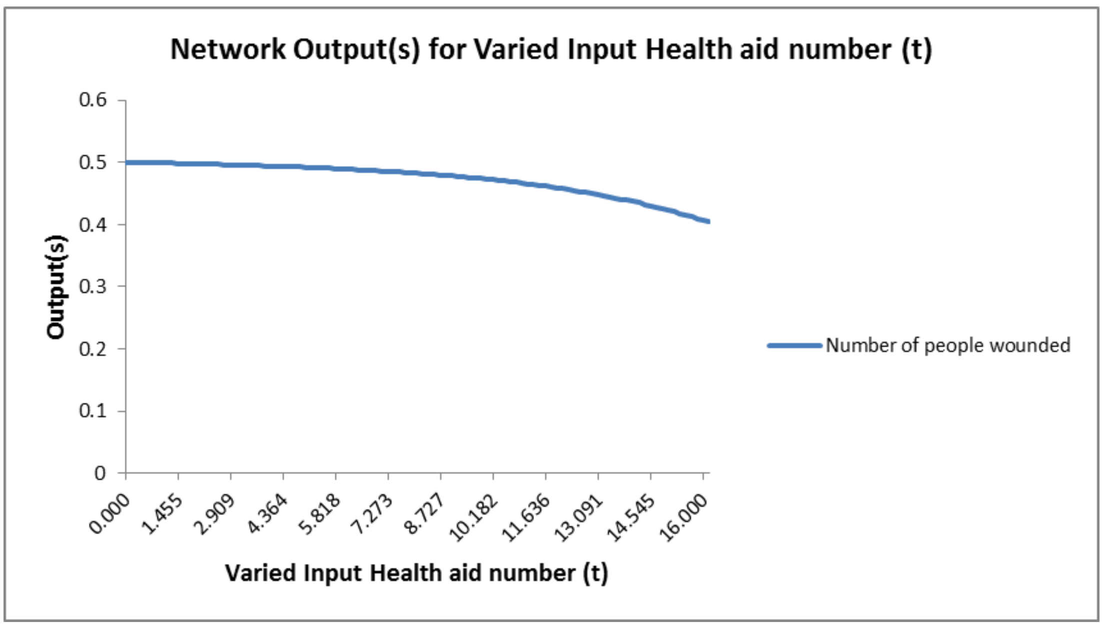


Figure 175: The effect of the second ranked independent variable on number of people wounded in Western region

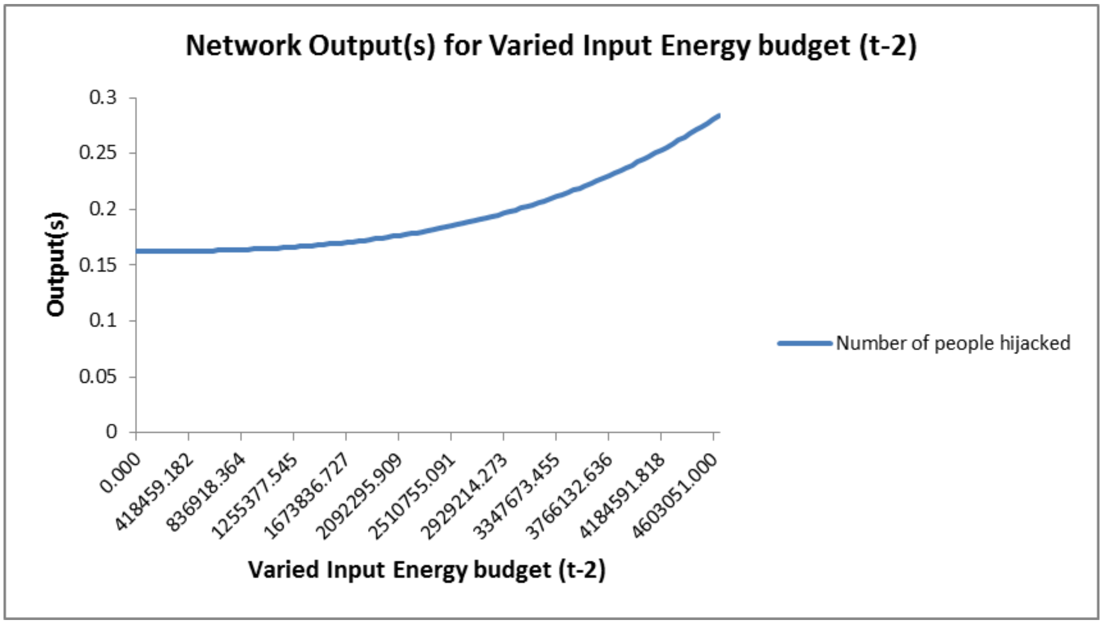


Figure 176: The effect of the first ranked independent variable on number of people hijacked in Western region

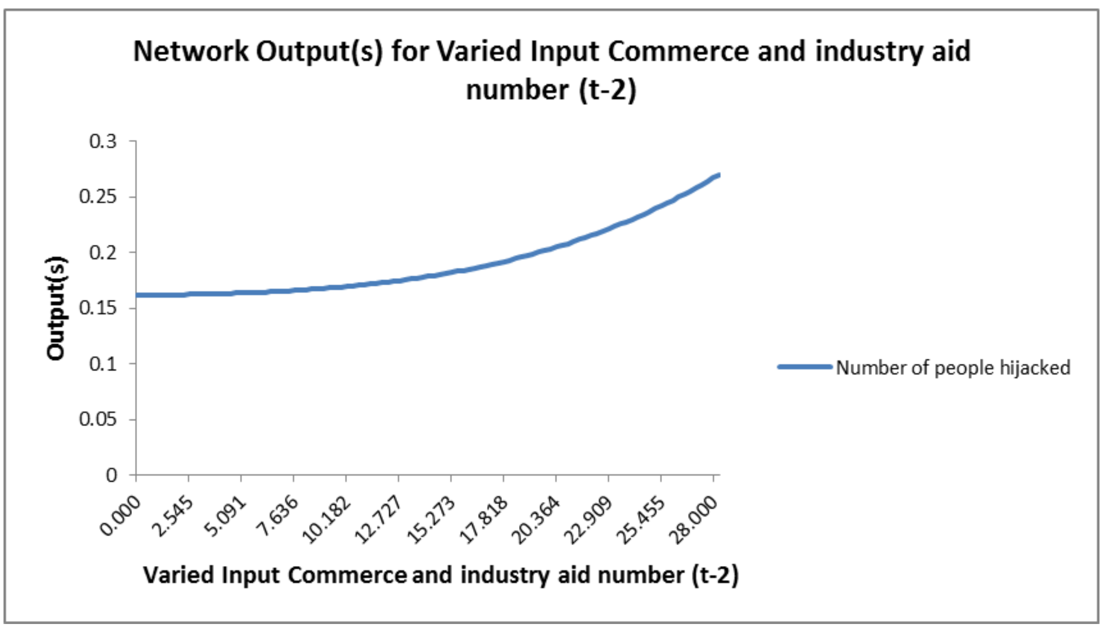


Figure 177: The effect of the second ranked independent variable on number of people hijacked in Western region

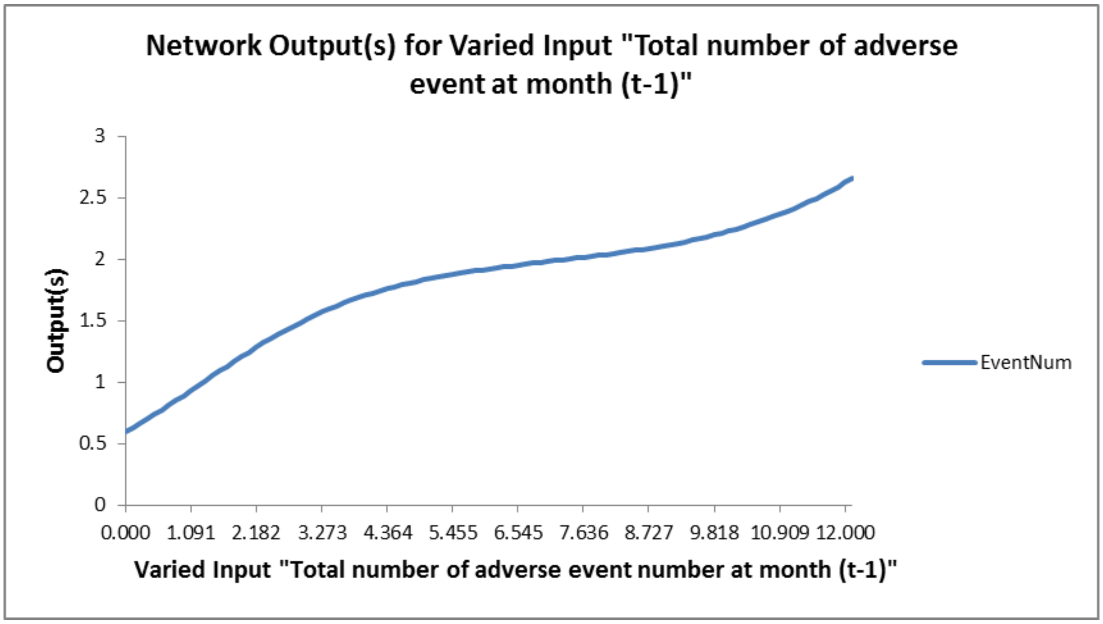


Figure 178: The effect of the first ranked independent variable on total number of adverse events in Western region

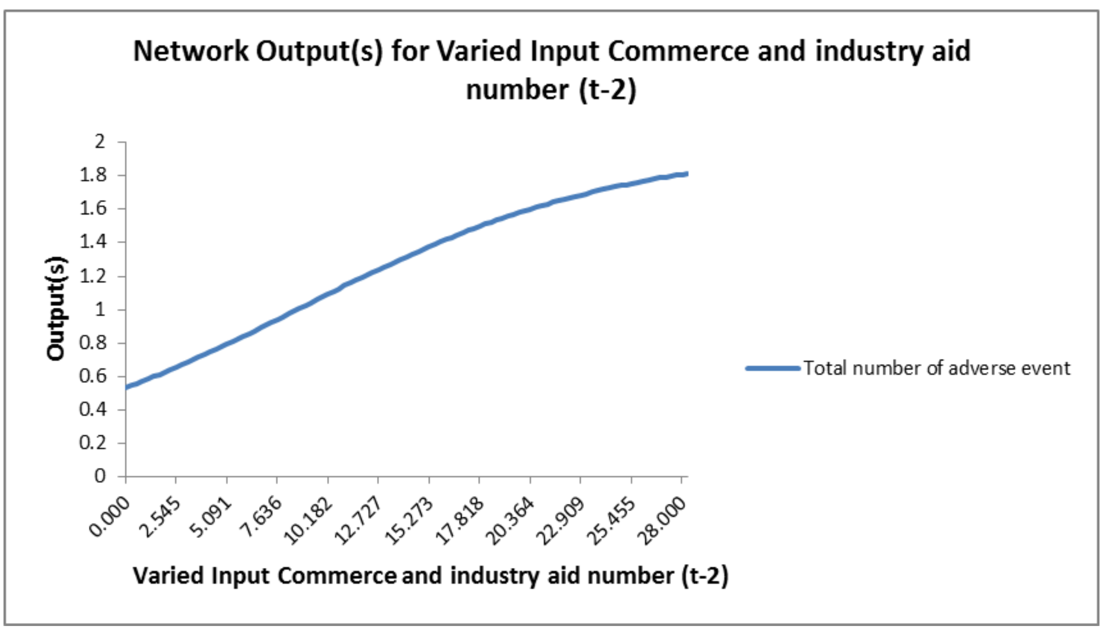


Figure 179: The effect of the second ranked independent variable on total number of adverse events in Western region

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